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ORIGINAL ARTICLES.

I.—Note on the Orbitoidal Limestone of North Borneo.

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(PLATE XIV.)

THE specimens which form the subject of the present note were brought to England by Mr. H. T. Burls, A.R.S.M., F.G.S., late Geologist to Rajah Brooke, of Borneo.

It was Mr. Burls's intention to communicate to the Geological Magazine the results of his observations in North Borneo, and in this connection I undertook the examination of the limestone with a view to obtaining evidence as to its age. On his departure for South Africa, Mr. Burls left the specimens at the Science Schools, asking me to make what I could out of them without stratigraphical details.

Under these circumstances the present communication has only the value of adding a few particulars to our knowledge of one of those limestones in the Dutch East Indies which have been loosely grouped together as Nummulitic.

The rock is a hard, compact, partly crystalline limestone, with specks of iron oxide and thin streaks of calcite, showing little trace of organic structure on a freshly broken surface, and altogether one that from its physical characters might readily be supposed to come from a formation of much earlier date.

Two specimens, which I understand to be from Silungen in Soubis, are of a brown colour, and differ from the others in the species of *Orbitoides* that form their chief organic constituent.

The remainder from Batu Gading, a locality considerably further inland, to the south, are pale grey in colour, and, where partly polished by the action of running water (having been collected in a stream-bed), show sections of thin *Orbitoides* discs in great numbers.

Under the microscope both rocks are seen to consist of a granular calcareous ground-mass, in which numerous more or less perfect organic remains, chiefly of Foraminifera, are embedded (Pl. XIV. Fig. 2). These and the cracks and interspaces of the rock are filled in with crystalline calcite.

After boiling in acid an insoluble residue is left, consisting of fine argillaceous material, with a considerable number of minute quartz

crystals. The only organic body observed in the residue was a fragment of a hexactinellid sponge.

The Foraminifera, so far as they can be identified with any certainty in section, are *Miliola*, *Nodosaria*, *Textularia*, *Globigerina*, *Amphistegina*, *Heterostegina*, and *Orbitoides*. The naming of Foraminifera which lie in a hard rock at all angles to the plane of section is unsatisfactory work at best, and I must trust to the accompanying figures to justify my identifications (see Plate XIV.).

The difficulty is still greater in the discrimination of species of *Orbitoides*, and in this case I have attempted determination only in the case of approximately median sections. Moreover, the study of this genus, comparatively simple in the days when only two types were recognized, has become a matter of considerable trouble since the researches of Dr. Gümbel[1] have raised the number of species to over twenty, necessitating in his opinion the establishment of five subgenera.

Orbitoides from N. Borneo.

O. (*Discocyclina*) *papyracea*, Boubée, sp.,[2] Pl. XIV. Fig. 5.

Some large forms occurring in the Silungen limestone appear to belong to this widely distributed and variable species, the *O. Fortisii* and *O. Pratti* of English writers. Dr. H. B. Brady[3] has recorded it from Sumatra, and it is common in the Nummulitic formation of Scinde.

O. (*Discocyclina*) *ephippium*, Sow. sp.,[4] Pl. XIV. Fig. 4*a*, *b*.

To this species, which has a similar structure to that of *O. papyracea*, but differs from it in its saddle-shaped curvature, I have referred several forms in the Silungen limestone. They are larger and thicker than those figured by Gümbel from the Alpine Eocene, and by Dr. K .von Fritsch from Borneo,[5] but not more so than the original type. In the several examples in the Borneo limestone the symmetry of the curvature, together with the absence of intermediate forms, prevents one from regarding them simply as abnormally grown individuals of *O. papyracea*. The species is well known from the Scinde formation.

O. (*Discocyclina*) *dispansa*, Sow. sp.,[6] Pl. XIV. Fig. 6.

Small thick lenticular forms, with large embryonic chambers and thick columns, corresponding to a marked surface tuberculation, seem to be without doubt referable to this species. The examples are similar in shape to those recorded by Dr. Brady from Sumatra,[7] while those figured by Dr. K. von Fritsch from Borneo are of the variety with wider disc. The species is also common in the Scinde formation.

[1] Abh. d. k. bayer. Akad. Wissenschaft., München, Bd. x. Abth. 2, pp. 501-730, Taf. 1-4 (4to.), 1868.
[2] Bull. Soc. Géol. France, vol. ii. 1832, p. 445.
[3] Geol. Mag. Vol. II. 1875, p. 535, Pl. XIV. Fig. 1.
[4] Trans. Geol. Soc. ser. 2, vol. v. 1840, Explan. pl. 24, fig. 15.
[5] Palæontographica, 1878, Supp. iii.
[6] *Op. cit.* p. 327, pl. 24, figs. 15, 16.
[7] *Op. cit.* p. 536, pl. 14, fig. 2.

O. (*Discocyclina*) *applanata*, Gümbel.,[1] Pl. XIV. Fig. 3*a*, *b*, *c*, *d*.

While the Silungen limestone contains the thicker, more lenticular forms mentioned above, the specimens from Batu Gading are full of a thin, discoid, umbonate species apparently the *O. applanata* of Gümbel. In vertical section they are seen to possess a median plane of rectangular chambers, and only three or four layers of lateral chambers on each side, except at the central umbo. The solid columns are not prominent. Numerous horizontal sections evidently of the same form show that the chambers of the median plane are rectangular and narrow, the radial measurement often four times the tangential. This character, together with the shape, would seem to decide its position in this species. Gümbel mentions its occurrence in Scinde.

O. (*Asterocyclina*) *stellata*, Gümbel.[2] Pl. XIV. Fig. 7.

The stellate *Orbitoides* included by Dr. Gümbel in this subgenus have a sufficiently characteristic appearance when cut horizontally to admit of recognition even in a rock section. One of them occurs in the Batu Gading limestone, and is apparently a young form of this species.

O. (*Lepidocyclina*) *Mantelli*, so abundant elsewhere, does not appear to be present, nor any of the *Rhipidocycline* species. There are several small thick forms of the size of *O. Sumatrensis*, Brady,[3] but they have large embryonic chambers, and seem to be young forms of other species.

Nummulites itself seems to be absent.

The only other fossil is a coral in the Silungen limestone, which Prof. P. Martin Duncan has kindly examined, and refers to the genus *Stylophora* (Pl. XIV. Fig. 1). As this is a common type throughout the Tertiary rocks, its occurrence is of little stratigraphical value.

With regard to the age of the Orbitoidal limestone, there is little to be said until more is known of its position and stratigraphical relations.

The limestones and associated beds of Java have been doubtfully regarded as Eocene, an opinion supported by the resemblance of their Molluscan fauna to that of the older European Tertiaries. According to von Richthofen,[4] however, the associated plant-remains pointed distinctly to their being at the oldest Miocene, and this view was supported by the discovery that what had been taken for Nummulites were Orbitoides, and by the suggestion, so strongly enforced by Dr. Duncan's examination of the Scindian Corals,[5] that parts of the Indian 'Nummulitic' formation were probably Miocene. It is worth noticing also that in Sumatra[6] the Orbitoidal limestone occurs at the top of a series of Tertiary beds.

[1] *Op. cit.* p. 122, pl. 3, figs. 17, 18. 35, 36, 37.
[2] *Op. cit.* p. 135, pl. 2, fig. 115 ; pl. 4, figs. 4–7.
[3] *Op. cit.* p. 536, pl. 14, fig. 3.
[4] See H. M. Jenkins' Summary, Q.J.G.S. vol. xx. 1864, pp. 62–72.
[5] See Palæontologia Indica, ser. xiv. vol. i. pt. i. Sind Fossil Corals, 1880, pp. 3–14.
[6] Verbeek, Geol. Mag. 1875, p. 479.

The specimens now under consideration do not affect the question decidedly either way. The fact that all the forms mentioned above occur in the European Eocene would appear to be an argument in favour of the Eocene age of the rock. The Eocene facies of the Foraminiferal fauna may, however, be due to that eastward migration which appears to have taken place, and which may account for the character of the mollusca in strata that would otherwise be looked upon as Miocene.

Amphistegina and *Heterostegina* are rather Miocene than Eocene genera, and in an Eocene limestone of this kind one would expect to find Nummulites associated with the Orbitoides.

Dr. K. von Fritsch's *Patellina trochus* from Borneo[1] very probably comes from beds below the limestone, and in its form and size it seems identical with the small pointed forms occurring in the Cretaceous of Navarre. The large fossil *Patellinæ* have been regarded as characteristic of the Cretaceous and Eocene, but they undoubtedly range above the Eocene, and specimens in the Science Schools Collection from the Miocene of Jamaica occur associated with *Orbitoides*, *Amphistegina*, and *Heterostegina*.

On the whole, therefore, though the species of *Orbitoides* are among those which characterize the Eocene rocks in Europe, there is good reason for defending the suggestion that the Orbitoidal Limestone of Borneo may be of a later date.

The work on these specimens has been done in the Geological Laboratory of the Normal School of Science and Royal School of Mines, and I have to thank Professor Judd, F.R.S., for the facilities afforded me in the preparation of sections, etc.

EXPLANATION OF PLATE XIV.

Figures of Orbitoidal Limestone of North Borneo.

Fig. 1. *Stylophora*, sp. × 20.
Fig. 2. Section of the Limestone of the Batu Gading, showing *Miliola*, *Nodosaria*, *Textularia*, *Amphistegina*, *Heterostegina*, and *Orbitoides applanata*, Gümbel × 12.
Fig. 3. *O. (Discocyclina) applanata*, Gümbel.
a. As seen in the water-polished surface of rock.
b. In vertical section × 2.
c. ,, ,, × 100.
d. ,, ,, × 12.
Fig. 4. *a*. *O. (Discocyclina) ephippium*, Sow. sp.
b. In section × 15.
Fig. 5. *O. (Discocyclina) papyracea*, Boubée, sp.
Fig. 6. *O. (Discocyclina) dispansa*, Sow. sp.
Fig. 7. *O. (Asterocyclina), stellata*, Gümbel.

II.—On the Genus *Ascoceras*, Barrande.

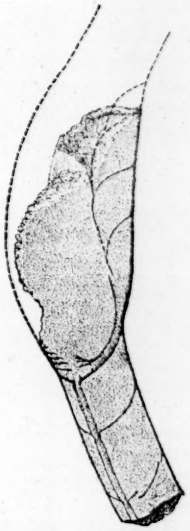
By Professor G. Lindström, of Stockholm.

THE uppermost limestone stratum of Gotland, which occupies two-thirds of the surface of this island, and is homotaxial with the English Upper Ludlow, contains such numerous fragments of Cephalopoda, that it has been called the Cephalopodan Limestone. Judging from the collection in the Palæontological Depart-

[1] *Op. cit.* p. 145.

ment of the Swedish State Museum, the number of species of Cephalopoda from the different strata of Gotland can hardly fall short of 200, most of them in a very perfect state of preservation, some even retaining the surface ornamentation and colour. Amongst them the genus *Ascoceras* (including *Glossoceras*), with its nine species, is the most remarkable. As the Museum has succeeded in obtaining specimens showing its morphology more completely than has hitherto been known, a few remarks on it may be made in advance of a monograph now in preparation.

The annexed figure represents a longitudinal section of a specimen from the uppermost limestone. It is imperfect on the ventral side, but the characteristic septa along the dorsal side show distinctly that it is an *Ascoceras*. We see here two essentially different parts of the shell: *first*, a lower part in which two entire air-chambers and a portion of a third yet remain, which are fashioned, after the common Nautilidean type. The *second* or upper portion in immediate continuation and connexion with the former, is the *Ascoceras* properly so called. The entire shell must have been arcuate or gently curved, like some forms of *Cyrtoceras*, but it is doubtful if complete specimens ever existed, since several examples clearly show that the older parts of the shell were, at certain intervals, regularly cast off or decollated.



Ascoceras sp., U. Ludlow, Isle of Gotland.

The truncated end appears in all cases to have been strengthened from within by fresh linings of shelly material, and the animal continued to secrete its shell till the *Ascoceras* portion was formed. When this was finished, at least exteriorly, the older portions of the shell were, as a rule, decollated, and hence the *Ascoceras* usually occurs by itself without the early, or *Nautilus* stage, and specimens like that figured are extremely rare, and in fact, only a few examples from Gotland have as yet been discovered.

This strange and abnormal Cephalopod thus went through two sharply-defined stages during its growth, the *first*, probably of longest duration, the *Nautilus*, and the *second*, the *Ascoceras* stage. Broken-off stumps of the former stage have been found, which can be matched to five of the nine Gotland species of *Ascoceras*. They all show the characteristic peculiarities of a narrow thin shell, very gradually increasing in width, oval or elliptical in transverse section, and ornamented by oblique, transverse striæ. The body-chamber

is extraordinarily long, the intervals between the septa, at first short and irregular, become during the progress of the growth, unusually long. The siphuncle is narrow and straight, generally situated near the ventral surface. The decollation is oblique, following the direction of the septa.

The commencement of the *Ascoceras* stage is partially indicated by the increased distance between the septa. Very important changes in the shape of the animal, and probably also altered functions must have supervened, when its shell, thus rapidly, as it were, developed the very abnormal *Ascoceras* form. The septa were pushed up along the dorsal, and greatly depressed along the ventral side, where also the cochleate or bullate siphuncle is placed. In no other genus of the Cephalopoda are such aberrant septa developed. The most curious feature is that, with the exception of the lowest or oldest one, they are all incomplete, having a large lacuna in their central part on the dorsal side. They have thus been secreted only along the interior wall of the shell, leaving an empty space between their thin linings. Hence the different aspect they present in many of the figures in various publications. Thus they are continuous along the outside of a cast of the interior (Barrande, Céphalopodes, pl. 93, fig. 1), and truncated, discontinuous and resting on each other in a median, longitudinal section (Barr. *l.c.* pl. 93, fig. 4).

The discovery of these Gotland specimens of *Ascoceras* fully confirms the views of Bronn, expressed in 1855, at a time when neither he nor any one else had seen perfect specimens, as to the relationships of this genus. Barrande stated that *Ascoceras* possessed only a single deciduous chamber below the "lateral chambers," and he regarded the genus as the prototype of *Nautilus*. Bronn, on the other hand, invited by Barrande to give an opinion on the subject, suggested that if *Ascoceras*, at an early stage, threw off a portion of its growth, consisting of regular air-chambers with a siphuncle, then "*Orthoceras is rather to be designated as the early stage of Ascoceras*" (Neues Jahrbuch für Mineralogie, etc., 1855, p. 283, footnote **).

III.—Ostracoda from the Weald Clay of the Isle of Wight.

By Prof. T. Rupert Jones,[1] F.R.S., etc.

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4. *Cypridea Dunkeri*, Jones.
5. *Cypridea spinigera* (Sow.).
6. *Cypridea Austeni*, Jones.
7. *Darwinula leguminella* (Forbes).
8. *Cyprione Bristovii*, Jones.
9. *Metacypris Fittoni* (Mantell).

SOME new species having been found in the Isle of Wight during the lately renewed examination of its geology by the Geological Survey, and the known Wealden species of that island not having

[1] Mr. C. D. Sherborn, F.G.S., has kindly assisted the writer in the examination of these Ostracoda.

been hitherto so distinctly indicated as might be, it is thought advisable to give some notes on, and a résumé of, this interesting series of fossil species.

1. Cypris cornigera, sp. nov. Figs. 1*a*–1*f*, p. 536.

Valves suboblong; straight on the dorsal; elliptically rounded on the ventral margin; unequally rounded at the ends. Bearing a delicate sharp spine, or straight horn, at the front end of the dorsal line, pointing obliquely upwards (outwards and forwards). The extremities of the valves differ much in individuals, according to the state of preservation, and possibly according to sex. The front end is highest (broadest), and often boldly rounded, but sometimes showing a slight outward and downward slope at its upper part, just in front of the horn. The horn is, or has been, present on examples of both right and left valves, but it has very often been lost, and we have not been able to see it in place in a closed carapace.

The highest end, that which bears the spine, is also the most compressed (Fig. 1*f*); and therefore in all probability is the anterior; and hence the larger valve, overlapping the other ventrally, is the left (Fig. 1*e*).

The anterior and posterior margins of the valves are slightly bevelled on the inside. The hinge-line is simple. The surface is smooth; but, readily dissolving away, both inside and out, into numerous little pits with rounded mouths, according to some structural peculiarity, the valves appear to be coarsely and irregularly punctate in many instances.

This species occurs in two specimens of dark-grey shale, marked No. 3685 and No. 3688 (Geological Survey), from Atherfield Point, Isle of Wight. In the latter piece of shale it was associated with *Metacypris Fittoni* and a Fish-bone.

2. Candona Mantelli, sp. nov. Figs. 2*a*, 2*b*, p. 536.

In a light-grey compact shale (No. 3791, Geological Survey), from the Wealden beds between Atherfield Point and Shepherd's Chine, there are on the bed-planes many Ostracoda belonging to *Metacypris Fittoni* (Mantell), small; *Cypridea spinigera* (Sow.), young individuals; *Cypridea tuberculata* (Sow.); *Cypridea Valdensis* (Fitton); and *Candona Mantelli*, sp. nov.

The last somewhat resembles *Candona candida*[1] (Müller), and is evidently allied both to that species and to *C. Phillipsiana*, Jones (Geol. Mag. 1878, p. 108, Pl. III. Fig. 3), but the latter is too large, and much too high and less symmetrical. In the form before us the posterior extremity is more evenly rounded than in *C. candida*, and the anterior is not so high. Of the new species the right valve figured in outline (Fig. 2*a*) is the largest and best preserved of the many specimens on the shale.

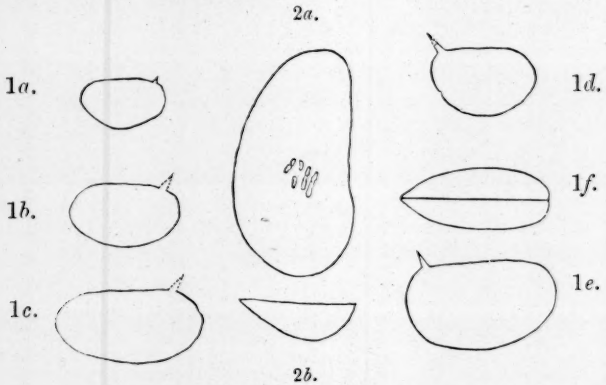
Subreniform, broader (that is, higher), and more boldly curved behind than in front; elliptically arched on the back, slightly sinuous on the ventral margin. Surface smooth and very delicately

[1] See Geol. Mag. 1878, p. 108, *footnote*.

punctate; almost equally convex, but sloping more rapidly in the dorsal region; hence the edge-view of the carapace would be lanceolate, and the end-view (Fig. 2*b*) acute-ovate. The ventral margin has a minutely-frilled appearance, which is lost, however, where the edge curves inwards at the middle.

The spots marking the muscular attachment on each valve consist of four oblique, parallel, but rather irregular, rows of little oval marks. These are in pairs, which unite at their ends in three, but remain separate in one, of the groups. On the inside of the valve the spots are little depressions; on the outside they appear translucent. The pattern is more like that of *Cypris* (*Candona*) *reptans* (fig. 7*e*, pl. 1, Monogr. Tert. Entom.), than that of *Candona candida*; the direction, however, of the rows of little marks is from the postero-dorsal to the antero-ventral region, which is contrary to the usual condition for muscle-spots in such a form of valve.

As this *Candona* differs from those already known, I propose to name it after my old friend the late Dr. G. A. Mantell, one of the most zealous elucidators of the geology of the Isle of Wight, and of its Wealden strata in particular.



Cypris cornigera, Jones.
- Fig. 1*a*. A right valve of a young individval.
- ,, 1*b*. A right valve of medium growth.
- ,, 1*c*. A long and low (narrow) variety; right valve.
- ,, 1*d*. A short and high (broad) variety; left valve.
- ,, 1*e*. The largest specimen; outline of left valve.
- ,, 1*f*. The largest specimen; outline of edge-view of carapace.

Candona Mantelli, Jones.
- Fig. 2*a*. Outline of a right valve. (Anterior end placed upwards.)
- ,, 2*b*. Outline of the end view of the valve.

Magnified 20 diam.; drawn by Mr. C. D. Sherborn, F.G.S.

3. Cypridea[1] Valdensis (Fitton).

This was the *Cypris faba* of Sowerby, "Mineral Conchology."

[1] This genus is described at large in the Quart. Journ. Geol. Soc. vol. xli. 1885, p. 336. Remarks on the possible alliance existing between *Cypridea* and *Chlamydotheca* have been made by Dr. G. S. Brady in the "Proceed. Zool. Soc." 1886, p. 90; and in the "Journ. Linn. Soc." vol. xix. 1886, p. 200, 201.

1824, pl. 485, pp. 136–8; and was named *Cypris Valdensis* by Dr. Fitton[1] in 1836. See Geol. Mag. 1878, p. 109 and 277, Pl. 3, Fig. 11; and Quart. Journ. Geol. Soc. vol. xli. 1885, pp. 315–318, and 336–337. It is of very general occurrence in the Wealden beds,[2] especially the Weald Clay, and notably in the dark and thinly-laminated shales at Compton Bay in the Isle of Wight. It occurs, but is rare, in the Purbeck beds of Dorset.

4. Cypridea Dunkeri, Jones.

Cypridea Dunkeri, Jones, Quart. Journ. Geol. Soc. vol. xli. 1885, p. 339, pl. 8, figs. 9, 10, 17.

To the synonyms mentioned at p. 339, *op. cit.*, add:

Cypridea granulosa (Dunker), Jones, Geol. Mag. 1878, p. 110, Pl. III. Fig. 16.

This species is rather rare, but occurs in the Weald Clay of Grange Chine,—West of Brook Point,—Brixton Bay,—Atherfield,—and Sandown, in the Isle of Wight. It is rarer elsewhere, but has been found in the Wadhurst Clay and the Netherfield Limestone of Sussex, and in the Upper and Middle Purbeck beds of Dorset.

5. Cypridea spinigera (Sowerby).

Cypris spinigera, Sowerby, in Fitton's Memoir "On the Strata below the Chalk," Trans. Geol. Soc. ser. 2, vol. iv. 1836, p. 345, pl. 21, fig. 3. Figured also by Mantell, Lyell, and other authors.

Cypridea spinigera, Jones, in Morris's Catal. Brit. Foss. 1854, p. 104.

Cytherideis unicornis, Jones, Mem. Geol. Surv. Isle of Wight, 1856, p. 158, pl. 7, figs. 24–26; Monogr. Tert. Entom. 1856, p. 48.

Cypridea Valdensis, Bristow, Mem. Geol. Surv. Isle of Wight, 1862, p. 4, fig. 1.

Cytherideis unicornis, Jones, Geol. Mag. 1870, pp. 157, 158.

Cypridea spinigera, Jones, Geol. Mag. 1878, p. 109.

——————— Jones, Q.J.G.S. vol. xli. 1885, pp. 316, 333, and 334.

——————— Jones and Sherborn, Geol. Mag. 1887, p. 386.

In the Quart. Journ. Geol. Soc. 1885, *Cypridea spinigera* was mentioned as being common in the upper part of the Weald Clay at Compton Bay, Atherfield, and Sandown in the Isle of Wight, and as occurring also in the Wealden beds, but more rarely, of Sussex and Surrey. We now find that it occurs abundantly in the Tertiary beds of Hamstead Cliff on the north coast of the Isle of Wight. Specimens from this locality were described and figured in the Geol. Surv. Memoir I. of W. 1856, under the name of *Cytherideis unicornis*, as a subreniform Ostracod, sulcate and tuberculate when young, but with a sharp spine on each valve when adult. Careful examination of a further series of specimens leaves no doubt that it is the same species as that so plentiful in some of the Wealden strata. The Tertiary specimens are not so well preserved as those in the Wealden clays, nor are they so abundant; but many perfect specimens, young and adult, can be readily matched from the two formations. The Tertiary specimens are plentiful in a crushed state on the laminæ of a dark-grey marl ("D 6," Geol. Survey) of the Lower Hamstead series, Hamstead Cliff.

Note.—This species, or one extremely like it, has turned up in a specimen given to me by the late Dr. Mantell as coming from the

[1] Another species (*Cypridea Austeni*) was figured in his memoir instead of the true *Cypridea Valdensis*. See Geol. Mag. 1878, p. 277.

[2] See Q.J.G.S. 1885, pp. 333 and 334.

Oxford Clay of the Trowbridge Railway-cutting, Wiltshire, and also in a piece of the Oxford Clay of Skye, collected by Messrs. Geikie and Young, and there associated with *Estheria*. If its freshwater habitat in the Hamstead series be a criterion, and if these other specimens prove trustworthy, it points to more freshwater or estuarine conditions in the Oxfordian Series than are usually thought of.

6. Cypridea Austeni, Jones.

Cypris Valdensis, Fitton (*in part*), Trans. Geol. Soc. ser. 2, vol. iv. 1836, p. 204, etc., pl. 21, fig. 1. Copied by various authors.
——————— Mantell, Wonders of Geology, 7th edit. 1857, vol. i. p. 419, lignogr. 104, fig. 3.
——————— Lyell, Elements of Geology, 6th edit. 1865, p. 346, fig. 341.
——————— Mantell, Geol. Excurs. Isle of Wight, 3rd edit. 1874, p. 223, lignogr. 25, fig. 3.
Cypridea Austeni, Jones, Geol. Mag. Dec. II. Vol. V. 1878, pp. 109, 110, 277, Pl. III. Fig. 8.

This oblong *Cypridea* was figured by Fitton instead of the real ovate *C. Valdensis*, and it has been often copied for the latter. The figures in Mantell's works quoted above are given by him as representing specimens from the Wealden beds at Brook Bay, Isle of Wight. As such they may be noticed here, although possibly *C. Valdensis* may have been really intended, and the figure copied from Fitton by mistake.

In the same lignograph Mantell gave a figure of *Cypridea spinigera* (after Sowerby's drawing), as having also been got from Brook Bay. He also copied his fig. 2 from Sowerby's fig. 4 in Fitton's Memoir, namely, *Cypridea granulosa* (Sow.), the same as *Cypridea fasciculata* (Forbes), as an Isle-of-Wight specimen; but that was certainly an error, for that species occurs only in the Middle Purbeck beds. See Q J.G.S. vol. xli. pp. 340–342.

Cypridea Austeni has been found at Peaseworth, in Surrey, and at Shotover, near Oxford.

7. Darwinula leguminella (Forbes).

Quart. Journ. Geol. Soc. vol. xli. 1885, pp. 332, 333, 346, pl. 8, figs. 30 and 31.

This little Ostracod occurs in the Weald Clay at Atherfield and Sandown; also in some Wealden beds of Sussex and Kent, in the Upper and Middle Purbecks of Dorset, and the so-called Wealden (Purbeck ?) beds of North Germany. In the Geol. Mag. April, 1886, p. 147, Pl. IV. Figs. 4 *a*, *b*, *c*, this species is recorded also from a Jurassic freshwater bed in Colorado.

The genus is the type of a separate family according to Brady and Robertson, "Monogr. Post-Tert. Entom." 1874, pp. 116 and 140. As the name was changed from *Darwinella* to *Darwinula*, the family name is now *Darwinulidæ*. *D. Stevensoni*, B. and R., is abundant in the fen rivers of the East of England.

8. Cyprione Bristovii, Jones.

Quart. Journ. Geol. Soc. vol. xli. 1885, p. 344, pl. viii. figs. 27, 28, 29, 32.

An additional occurrence of Wealden Ostracoda discovered by the Geological Surveyors in the Isle of Wight is a hardish buff-coloured marl, marked "3908," from the "Wealden Cliff opposite Compton

Chine," crowded with *Cypridea Valdensis, Cypridea Dunkeri, Metacypris Fittoni,* and *Cyprione Bristovii.*

The last-mentioned species has been found also in the Tunbridge-Wells Sand at Lindfield and Tunbridge (?), in the Wadhurst Clay near Hastings and Bexhill, in the Upper and Middle Purbeck beds of Dorsetshire, and in the equivalent beds of North Germany.

Cyprione probably belongs to the *Darwinulidæ.*

9. Metacypris Fittoni (Mantell).

Cypris tuberculata, Sow. *(in part)*, Trans. Geol. Soc. ser. 2, vol. iv. 1836, pp. 177, &c., pl. 21, fig. 2 *a*.

Cypris Fittoni, Mantell, Medals of Creation, 1844, vol. vii p. 545, lignograph 119, fig. 2.

Cypridea ? Fittoni, Jones, Geol. Mag. 1878, p. 277.

Cythere Fittoni, Jones. Quart. Journ. Geol. Soc. 1885, vol. xli. p. 333.

Metacypris Fittoni, Jones, in Prestwich's 'Geology,' vol. ii. 1888, p. 263, fig. 137*a*.

This species is common in some beds of the Weald Clay of the Isle of Wight, especially at Compton Bay,—on the west of Brook Point,—at Brixton Bay,—at Atherfield, and Sandown Bay. It occurs also at Punfield Cove near Swanage, and at Pulborough and Pallingham, Sussex, in the Weald Clay; in the Tunbridge-Wells Sands at Lindfield; and in the Wadhurst Clay near Hastings. It is not rare also at some places in the Weald Clay of Kent (near Maidstone, Great Chart, Aldington, and Hythe), and the Tunbridge-Wells Sands at Langton Green. Also (doubtfully) in the Weald Clay near Hazlemere in Surrey.

The genus *Metacypris* was first noticed by G. S. Brady in 'Nature,' 1870, p. 484; and was found living, but not abundantly, in the tidal waters and "Broads" of the East of England by G. S. Brady and D. Robertson. There was only one species (*M. cordata*) met with, and they determined it as more probably belonging to the Cytheridæ than to the Cyprididæ. See Ann. Mag. Nat. Hist. ser. 4, vol. vii. pp. 19, 20; vol. ix. p. 51; and Monogr. Post-Tert. Entom. 1874, pp. 112 and 116. Also Quart. Journ. Geol. Soc. vol. xli. p. 344.

Besides the *M. Fittoni* mentioned above, there are several other fossil species. *M. Forbesii* is one of the leading fossils of the Middle Purbeck beds of Dorset (Ridgway, Durlston Bay, and Mewps Bay), *op. cit.* p. 346. In the Geol. Mag. April, 1886, p. 146, Pl. IV. Figs. 1 *a, b, c,* this species is also described from a Jurassic freshwater or estuarine limestone of Colorado, where it is associated with two other species, namely, *M. Bradyi* and *M. Whitei*,[1] *loc. cit.* Pl. IV. Figs. 2 *a, b, c,* and 3 *a, b, c*. *M. conculcata*, Jones, from a similar estuarine formation at Bahia in Brazil,[2] as well as *M. strangulata*, Jones, from Tertiary beds in the Province of Nagpur, Central India,[3] are referred to in the same paper, pp. 146, 147.

One of the chief characteristics of *Metacypris* is the submedian transverse suture on the dorsal region. This is very strong in *M. Fittoni*, and is the feature which led Mantell to separate this species from its somewhat similar companion, *Cytheridea tuberculata.*

[1] These three species have been described briefly and figured in the 'Bulletin U.S. Geol. Surv.' No. 29, May, 1886, pp. 23, 24, pl. iv. figs. 22-26.

[2] Quart. Journ. Geol. Soc. vol. xvi. 1860, p. 266, pl. xvi. figs. 3 *a, b*.

[3] *Ibid*, p. 187, pl. x. figs. 73 *a, b, c, d.*

IV.—The Sculpture of Alpine Passes and Peaks.[1]

By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

THERE are two facts which are closely connected with the present condition of the Alps—(1) that the rainfall on the Alpine slopes on the Italian side of the watershed, as a rule, is heavier than that on the other side, and (2) that the valleys also are steeper. It is indeed true that the distance from the watershed of the Central Pennines to the lakes on either side, north or south, is not very different, but the level of those on the latter is some 700 feet below that of those on the northern. This difference of level is especially marked in the upper part of the valleys, places correspondingly situated being always lower on the southern than on the northern face; for instance, Zermatt is rather above Macugnaga, but as the crow flies it is more than double the distance from the watershed.

For both the above reasons denudation will proceed more rapidly on the slopes of the Alps facing southwards or eastwards, that is, towards Italy, and thus the valleys in them will be cut back more quickly and be more precipitous at their heads than in the northern or western slopes. From this results a singular configuration of the uppermost parts of a valley, which is commonly exhibited by the passes selected for the construction of high roads. The usual form of a pass in the higher Alps, as every climber knows, is this: you follow a valley which at last leads you by a final ascent, more or less steep, to a gap or saddle between two peaks, on the other side of which a similarly formed valley is found to descend. Of such passes every variety exists, from the depression which must be reached by climbing a rocky wall, like the east side of the Strahleck or the south side of the Sella Pass, to those like the Col de la Valpelline, where the final acclivity is comparatively slight. Occasionally, however, we meet with a type of pass of which the Maloya, at the head of the river Inn, may serve as an example. Noted as one of the lowest gaps across the watershed of the Alps, for its summit is barely 6000 feet above sea-level, its structure offers a problem which at first sight is sufficiently perplexing. The valley of the Inn ascends, on the whole gradually, to Samaden, where the river is joined by a torrent which carries the drainage from the northern face of the Bernina group. But though this brings the greater volume of water, it occupies a glen which is, orographically, of secondary importance, and the main valley continues onwards in a south-westerly direction towards the Maloya Pass. Samaden is about 5600 feet above the sea; from it a rather steep but short ascent brings us to the level of the St. Moritzersee, the elevation of which is about 5800 feet. We have now entered a rather broad and almost level valley, enclosed between mountains which rise on either side from 4000 to 6000 feet above it, the floor of which is occupied to a considerable extent by a group of shallow lakes. This trough is more than nine miles long; yet the Silsersee at its upper end is only 66 feet higher than

[1] An extract from one of the "Tyndall Lectures" delivered at the Royal Institution in 1888, by Prof. T. G. Bonney, D.Sc., F.R.S.

the St. Moritzersee; hence the fall is only 15 in 10,000, or, roughly speaking, about seven feet in a mile. The Maloya Kulm is a very short distance from the head of the Silsersee, and is only a few feet higher than it; the height assigned to the lake being 5872 feet, and to the pass 5942 feet. I doubt, indeed, whether the latter measurement indicates the lowest point, and think that it would be possible to divert the waters of the Silsersee from the Black Sea to the Adriatic by a comparatively shallow cutting. But no sooner have we traversed this low ice-worn floor of rock than the scene changes in a moment; we are standing on the brow of a series of lofty cliffs; the road swings away to the left to seek a less precipitous part of the enclosing head of the valley, to the floor of which—nearly a thousand feet below—it descends by a series of zigzags. To what are we to attribute this singular configuration: this flat, almost level trough driven right through the crest of the Alps, and terminating so abruptly at the brink of a range of precipices? There is the river valley—one which seems to suggest, nay, to demand, the action of strong torrents for its making—and no torrent is to be found, for the mountains from which it could flow have vanished, and instead of a ridge we have vacant air!

Is this trough the work of glaciers? Certainly it bears everywhere the marks of moving ice. Members of the School of Ramsay might cite its wide but shallow lake basins as examples of the excavatory power of ice, and here, though I could point out some difficulties in the application of their theory, I should not be surprised if their claim were substantiated. But the glacier which exercised any erosive action on this trough can only have been formed by the fusion of ice-streams which descended from the mountains on either side. Hence it may have modified the superficial features, but in no case can it be said to have excavated the trough, because, as already stated, there is not even a ridge at its head. Suppose the trough of the Maloya covered deep with snow and ice, it is obviously impossible that this can have exercised any erosive force of importance in the direction of the flow of the Inn, because here it would be almost at rest. Moreover, we can prove that when the glaciers of the Alps were vastly greater than now, and the Maloya was thus buried, the actual watershed of the pass—that is, the ice-worn rock on which the Kulm hotel now stands—was swept by a glacier which had its origin among the peaks on the southern side of the watershed—one represented at the present day by the Forno glacier; for on this rock are strewn erratics of the peculiar porphyritic granite which forms the crags on the western side of that glacier. We have only to stand on this ice-worn plateau among the erratics which mark the overflow of the southern ice-stream, to glance at one moment along the unbroken trough on the Swiss side, and the next down the steep crags into Italy on the other, in order to realize how slightly the glaciers of the Great Ice Age can have modified the pre-existent natural features of the district, and to justify us in assigning to them a very secondary place among the graving tools employed by Nature.

What explanation, then, must be given of this singular trough?

I regard it as anterior in its dominant features to the extension of the ice. I suppose that when it was made no glacier intruded on to its floor; perhaps there were no glaciers among the peaks; at any rate, I do not suppose that the region of snow and ice was more extensive than at present. I believe, for I can find no other explanation, that in this part of the valley of the Inn we have a true valley of erosion, comparable, let us say, with the upper part of the Val Rosegg, one of those steps which not unfrequently precede the final ascent to the watershed. But I suppose that the watershed in this case once lay some distance further south, perhaps not very far away from the present frontier-line between the Engadine and Italy, say passing somewhere above the site of Vico Soprano. From this ridge the Inn then flowed towards the north-east, while on the other side the Maira descended towards the south-west. At the present time the Maira falls about 2500 feet between Vico Soprano and Chiavenna, a distance of about 12 English miles, say full 200 feet a mile, and the Maloya Kulm is nearly 2400 feet above Vico Soprano, a distance of about 5 miles as the crow flies, giving a total fall of almost 5000 feet in some 18 miles of the river course, say 5 in 100 on the average; while the Inn, as has been said, descends at first almost imperceptibly, and between St. Moritz and the Finstermünz only falls 94 in 10,000, which is rather less than 1 in 100.

Obviously, then, apart from any consideration of rainfall, the erosive force of the Maira would be far greater than that of the Inn. Thus the streams of the former would bite more deeply into the dividing range than those of the latter. The intervening mountain mass was quarried away far more rapidly on the southern side, until at last the corrie at the head of the Maira ate its way back through the dividing ridge, and actually cut away the slopes by which the streams descending towards the Engadine were formerly fed. Thus I regard the floor of the Upper Innthal as the decapitated remnant of a very ancient valley, which, while important changes have been occurring on either side, has remained comparatively unchanged, because denudation must needs cease when its motive forces are gone. When the weapons are snatched from the hand of the destroyer, when his arm is paralysed, then he must cease from troubling and the weary may rest.

If we examine a good map of the district, we find an interesting confirmation of the explanation just offered. The tributary glens of a river system bear a general resemblance, as every one knows, to the branches of a tree—they tend to converge in the direction of the flow, as twigs unite to branches, and branches to the trunk. It is true that the changes from valleys of strike to valleys of dip give rise to sharp turns and "kinks," not unlike those in the boughs of an aged oak; but we rarely find a valley running almost in the opposite direction to that of the stream to which it is a tributary. Yet the long glens occupied by the Albigna and the Forno glaciers run due north, while the Maira for some distance is flowing almost exactly in the line of the former glen, but in the opposite direction.

Moreover, the mouth of the upland glen leading to the Forno glacier is as nearly as possible on the level of the Maloya Kulm: its floor is reached from the latter by a track which keeps nearly at the same level, though the torrent which plunges downwards to the Maira has gashed the rock over which it rushes. Hence I believe that the streams from the Forno and the Albigna glens formerly flowed into the Innthal, as those from the Fédoz and Fex still do, but that, as the corrie at the head of the Maira gradually receded in a north-easterly direction, it intercepted and diverted, as its floor was on a lower level than theirs, first the torrent from the Albigna glen, and then that from the Forno. The diversion of these streams would, of course, augment the erosive force of the Maira, and correspondingly diminish the amount of denudation in the upper part of the Innthal. Indeed, I think it probable that the torrent from the Forno glen has indirectly aided in producing the precipices which separate the Maloya Kulm from the floor of the Val Bregaglia.

Instances like the above are far from rare in the Alps. Most of the passes traversed by the great high roads, such as the Genèvre, the Cénis, the St. Gothard, the Lukmanier, to mention no others, furnish us with examples of a nearly level plain of considerable extent at their summits; they are, in short, troughs driven through the range, not sharp-edged saddles on the range. To all these—very difficult to understand on the hypothesis that the watershed has always occupied its present position—the above explanation may be applied. I will only mention one other case, because it is in a region of sedimentary rock, seems no less anomalous than that which I have been describing, and brings us to a district where another difficulty demands an explanation.

On the Toblacher plateau—the water-parting between the Rienz and the Drave—the Ampezzo road turns off to cross the southern range in its course towards Venice. It passes through a deep trench in the dolomite mountains. On the one hand rise the grand spires of the Drei Zinnen and the turretted wall of the Cristallo; on the other the vast altar-stone of the Croda Rossa, with many subordinate summits. From Toblach to Landro, from Landro to near Peutelstein, the road is almost level. The rise from the entrance to the Höllensteinerthal to the shallow Durrensee, in which the crags of the Cristallo are mirrored, is less than 600 feet, though the distance is full six miles; and for the remaining six miles the total ascent is hardly more than 250 feet. The trough is then suddenly interrupted, almost as at the Maloya Kulm. From the northern, or rather the north-western side of Monte Tofana, a glen comes sweeping round, the floor of which is some hundreds of feet below the level of the pass; to this a steep and narrow track was the only means of descent until the present road, with its series of zigzags, was constructed. When the floor of this glen is reached, a more gradual descent leads to Cortina, which is a little less than 4000 feet above the sea. Here, then, we have a repetition, though on a smaller scale, of the physical features of the Maloya; and here, also, I can find no other explanation of the apparent anomaly than that the watershed once lay rather further to the south, and that as the main feeder of the Piave

deepened the valley between the Tofana and the Cristallo *massif*, it gradually cut away the rocky wall which once closed the glen to the west of Schluderbach.

But the head of the Pusterthal itself presents us with a somewhat similar anomaly, and this, singularly enough, finds a parallel at the head of the Etsch. The watershed in the former, though between the Adriatic and the Danube, is curiously ill defined. It is a flattish drift-covered plain, barely 4000 feet above the sea, perhaps a third of a mile wide, guarded on the one side by the slopes and crags of the crystalline schists of the central range of the Tyrol, on the other by the magnificent dolomitic cliffs of the southern range. On the west—from Welsberg to Niederndorf (4 miles) there is a rise of about 260 feet; from the latter place to Toblach (3 miles) a further rise of 150 feet; and from Toblach to Innichen, on the east side (2 miles), a descent of less than 100 feet. Thus the floor of the trough for some five miles does not rise and fall more than about 100 feet, and the average slope is less than 1 in 100. In the next eight miles the fall is only about 225 feet, which is still more gentle. But then it becomes more rapid; the valley contracts, its floor descends more sharply as the river passes through the Lienzer Klause, a defile cut into the crystalline schists and about nine miles long. Lienz itself, 28 miles from Toblach, is about 1750 feet below that place, while Untervintl, which is about the same distance on the western side, is some 300 feet higher than it. Here, then, I conclude that the original watershed must be placed to the east of the Toblacherfeld, and that the Drave has cut its way back into the upper part of the glen of the Rienz.

The pass of the Reschen Scheideck, which leads from the upper part of the valley of the Etsch to the Finstermünz in the valley of the Inn, exhibits a structure in some respects similar to that which has just been described. The Malser Heide, on which the pass lies, is a long and comparatively level trough, the watershed of which is less than 5000 feet above the sea (4898 feet). Thence the road declines gradually to Nauders (4468 feet), and then drops rapidly down to the gorge of the Inn, the level of that river being about 3700 feet above the sea.

To explain the structure of the region, I must go back to the time when the Inn had excavated a valley which was both shallower and narrower than that which it now occupies. Suppose that its bed was then about 5000 feet above the sea, on the level of the Reschen Scheideck; at that time the head waters of the Etsch may have descended from a ridge, the watershed of which lay near to the channel of the Inn. Gradually, as the latter river deepened and enlarged its valley, the ridge would be eaten away, until at last the head of the Reschen Scheideck trough was exposed. Then the brow of the declivity towards the Inn (as the rocks here are not very durable) would be rounded off, so that the edge of the old trough would not remain sharp, as in the case of the Maloya, but would be gently bevelled in the upper part, and thus the actual watershed would travel slowly and almost imperceptibly eastwards.

Instances where apparent anomalies may be explained by the

principle of the unequal rate of recession of the heads of valleys on opposite sides of a line of water-parting might readily be multiplied, but I will notice only one other, and that briefly. Many of you will remember the structure of the Pennine Alps at the head of the Gorner glacier. Between the pyramidal summit of the Matterhorn and the *massif* of the Breithorn there is the marked depression crossed by the Théodule Pass—a breach in the rocky wall which is some two or three thousand feet deep; for the summits on either side are respectively 14,705 feet and 13,685 feet above the sea, while the crest of the chain at the Théodule Pass is barely 11,000 feet. From the Breithorn the rocky rampart continues practically unbroken, in a general easterly direction, as far as Monte Rosa, its peaks being well over 13,000 feet in height, and even the gaps between them only about 1000 feet less elevated. In fact, from the Breithorn to Monte Rosa the crest of the range is never less than 12,700 feet above the sea. It culminates in the vast ridge of Monte Rosa, the highest peak of which is 15,217 feet above the sea, after which the watershed between Switzerland and Italy runs north, and we find another gap similar to that above mentioned, except that here a comparatively level snow-field is terminated by abrupt precipices on the eastern side. Every one who has crossed by one of the Weissthor passes, or who has ascended the well-known snowy hump of the Cima de Jazzi, will remember the startling contrast between the long and gentle ascent over slopes of snow on the western flank, and the precipitous descent on the Italian side. Between Monte Rosa and the Strahlhorn (13,750 feet) there is a gap of about three miles wide, the flattened crest of which undulates a little on either side of 12,000 feet. Besides this, a line of peaks, only a little subordinate to that of which Monte Rosa forms a part, terminates abruptly with the Strahlhorn almost on the watershed, instead of being prolonged, as might have been anticipated, by a spur on the southern side. Of this apparent anomaly we have not far to go in order to find an explanation. The head of the Val Macugnaga, which is a huge corrie, has cut back into the *massif* of Monte Rosa, and is partly enclosed by its eastern spur, which runs towards the Pizzo Bianco. The drainage from this corrie, starting in a northerly direction, sweeps round towards the east, passing under the great wall of cliffs which, as already mentioned, descends from the edge of the snow-field feeding the Gorner and the Findelen glaciers, and from that at the head of the Schwarzenberg glacier east of the Strahlhorn. Hence I conceive that the Strahlhorn was once part of a great spur thrown off from a range which extended in a direction rather east of north from Monte Rosa, and was elevated perhaps a couple of thousand feet above the present edge of the Gorner snow-field. The Cima de Jazzi might be a remnant of another spur from this range, and it is a noteworthy fact that the Monte delle Loccie, a peak over 12,000 feet on the eastern spur of Monte Rosa, is almost exactly on the line of the Strahlhorn axis.[1]

[1] Possibly the curious shelf or trough of the Saas Weissthor is really the half of an old pass between the Strahlhorn and a missing peak.

This range has been cut away, as the great glen of Macugnaga was being deepened and enlarged, devouring the mountain group by which it is fed.

I pass on to another peculiarity, which admits of a similar explanation. Not unfrequently the higher peaks, especially in the district south of the Little St. Bernard, project slightly from the watershed on to the Italian side, like bastions from a wall. Such is the case with the Ciamarella, the Roche Melon, the Viso, and others. The Viso, indeed, is wholly an Italian mountain, for it is the culminating point of a long and deeply gashed spur, extending towards the south-east from the main range of the Alps. The course, indeed, of the line of watershed is suggestive, for it forms about the head of the river Guil (flowing westward) a kind of cusp, near the point of which is the Viso. On the northern side of this cusp rise the tributaries of the upper waters of the Po; on the other, the feeders of a hardly less important Italian stream, the Vraita. To understand the orographical structure, I look back to a stage in the process of mountain sculpture when the line of watershed passed over the summit of the Viso, and its crest, elevated to perhaps a couple of thousand feet above the present level, ran in the same general directions as it now does, but some distance on the Italian side. The Guil continued to cut its way back towards the main peak, though slowly, as the slope of the upper part of the valley is not rapid. The glens of the Vraita on the one side of the peak and of the Po on the other side worked their way back more rapidly, and devoured the actual crest of the range. The descent on the Italian side is much more rapid than on the French; from the gaps, by which the range can be crossed from the latter country, to Crissolo in the Val di Po, is a drop of nearly 5000 feet. The descent from the Col de Vallante to Château Dauphin in the Val Vraita is about as much, while on the French side it would require some miles more walking to reach this level. Thus the Viso has been left projecting as a bastion. But nearly simultaneously with the above recession, two ravines, one tributary to the Po, the other to the Vraita, were cutting back into the curtain wall which connected the bastion peak of the Viso wall with the retreating crest of the watershed, until at last the heads of these glens met, and formed a kind of high-level ditch which isolates the peak from the actual watershed.

A similar principle may be applied to explain a very common feature in the higher regions of the Alps—namely, that the culminating peaks of important spurs are often hardly less elevated than those on the watershed. As an example, let us return to the Pennine range in the neighbourhood of Zermatt. The two branches of the Visp are divided and are bounded respectively by lofty ridges. A line drawn along the crest of the westernmost ridge would pass across the gap occupied by the Zmutt glacier to the peak of the Matterhorn; that drawn along the central ridge, as already said, would pass above the vast cirque at the head of the Val Anzasca to the Monte delle Loccie, east of Monte Rosa, while that along the easternmost ridge ceases rather abruptly near the head of the Val

Antrona. On the first spur, full ten miles to the north of the Matterhorn as the crow flies, we find the Weisshorn, actually the higher by about 100 feet; the other peaks to the south being well above 13,000 feet, and the lowest gaps between them not much under 12,000 feet. Opposite to the Weisshorn rises the mass of the Mischabel-hörner, the highest peak of which almost reaches 15,000 feet, and there is no point in the range south of it till we have passed the Strahlhorn, which falls much below 12,000 feet, while its peaks are all over 13,000 feet above the sea. Lastly, in the rather less elevated range east of the Saaser Visp, we find peaks somewhat over 13,000 feet in height separated by passes which are not much below 12,000 feet. As may be inferred from what I have already stated, the principal gaps in the rocky rampart enclosing the head of the Gorner Visp correspond with the direction of its main axis, and of the tributary glens now occupied by the glaciers, Zmutt, Gorner, and Findelen. These gaps I attribute to the destruction of the original party walls by the recession of the heads of the Italian valleys. In order to comprehend the process by which the above-described structure has been produced we must dissolve away snow and glacier, and must replace the myriad millions of cubic yards of rock which have been removed by the action of water in all its forms. We will, however, for simplicity, suppose any covering of Secondary rocks already stripped off. We may then picture to ourselves a broad arch of crystalline rock, slowly rising, perhaps not without pauses, until its flattened crown is full three miles above the sea. Its chord extends from the present valley of the Rhone on the one side perhaps to the Italian plain on the other. Into this mass the streams which start from its higher surface cut deeply, working their way backwards, and excavating the valley, so that every peak is a "locus of least denudation," standing like one of those prisms of earth which excavators leave to indicate the amount which they have removed.

It may be asked why, if the above explanation be correct, do we not find spurs on the southern side of the Pennines comparable with those on the northern. I reply because they have suffered more from and have been partly destroyed by the more rapid recession of the valleys on this side. As their tributary glens enlarge, as the great corries at their heads are extended, laterally as well as backwards, so the intervening masses suffer from corrosion, and at last even the peaks, which have for long been spared, must obey the general law, "Dust thou art and unto dust thou shalt return."

But on this subject passing time forbids me to dwell longer. I will only say that I believe the principles which I have indicated to be of general application in all mountain regions. There are, however, two topics indirectly connected with questions of Alpine sculpture which call for a brief notice. These are (*a*) what effects have snow and ice as erosive agents compared with running water, and (*b*) to what extent have the Alps, in the past time, been occupied by snow-fields and glaciers? I have already said that I believe that, compared with torrents, glaciers are erosive agents of secondary

importance.[1] I may add that snow-beds appear to have, comparatively speaking, a protecting influence. Still, snow-fields and glaciers in the upper part of a range act as storehouses for the water, and so keep the torrents always full; the former also give rise to endless streams which have a plunging action, and form precipitous cliffs, as may be seen in cirques; the latter increase the erosive power of torrents by rendering their waters muddy. I believe, therefore, that, wherever there is unprotected ground, the process of excavation is aided and accelerated by the existence of snow-fields and glaciers in the upper parts of the ranges. Hence I should infer that the sculpture of the more elevated regions progressed most rapidly when that of snow and ice was least extended.

V.—On a Mode of Using the Quartz Wedge for Estimating the Strength of the Double-Refracton of Minerals in Thin Slices of Rock.

By Major-General C. A. McMahon, F.G.S.

In some cases it is of practical importance to petrologists to estimate the strength of the double-refraction exhibited by doubly-refracting minerals in thin slices of rock under the microscope.

Babinet's compensator, a description of which will be found in Rosenbusch's *Microskopische Physiographie der Mineralien und Gesteine*, affords a means of accurately calculating the refractive indices of the rays into which light is divided in its passage through doubly-refracting crystals. Michael-Lévy also devised another exact method based on observations made on the tints presented by slices of doubly-refracting minerals, an account of which appeared in the *Bulletin de la Société Mineralogique de France*, and which is discussed in a work recently published by Michael-Lévy and Lacroix.

As these exact methods of calculating the double-refraction of crystals require special apparatus and are somewhat complicated, it may be worth while to describe a rough and ready method based on the use of the quartz wedge, which I have employed for some years, and which has yielded me useful results.

In order to explain this mode of using the wedge, I will suppose, in the first place, that we have our microscope arranged on our table with crossed Nicols, and that we have inserted a quartz wedge, made in the usual way (which is too well known to need description), in a slot in the eye-piece at an angle of 45° to the plane of polarization. If we look through the microscope with the apparatus fixed in this position, and before any object has been placed on the stage, a series of chromatic bands will be observed in the quartz wedge, each band consisting of a spectrum of colours in an ascending order; the colours of the first order of Newton's scale being the nearest to the thin edge of the wedge. The width of these bands depends on the thickness of the quartz and on the slope of the wedge, being broader in a flat wedge than in one cut at a considerable angle.

The usual way of employing the wedge for the purpose of estimat-

[1] Discussed in a part of the lecture not included in this extract.

ing the strength of the double-refraction of minerals is to compare the tint of the mineral with the corresponding tint in one of the chromatic bands in the wedge. The eye of the observer may thus be trained to determine whether the tint of the mineral under observation belongs to the first, second, or higher order of Newton's scale. This method is based on the rule that the stronger the double-refraction of a mineral, the higher will be the order of the tint exhibited by it when sections of different minerals cut in slices of uniform thickness and at the same angle to an optic axis are examined in transmitted light under a microscope.

In working this method I employ a quartz wedge specially made for the purpose,[1] which is similar to the ordinary wedge in all respects but one; namely, my wedge only occupies half the depth of the slot, so that the observer is able to directly compare the tint

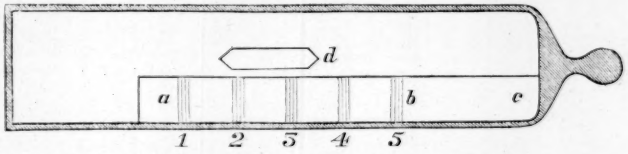


FIG. 1.—Diagram of quartz wedge used by the author.

of a mineral, say at *d* (Fig. 1), with the spectra seen in the wedge *a–b–c*, and so determine satisfactorily whether the observed tint belongs to the 1st, 2nd, or higher order of Newton's scale.

The method, however, which I desire to describe in the following pages differs from the above. It depends not on the order of the tint exhibited by the mineral under observation, but on the character of the phenomena produced in the quartz wedge by the passage of light through the mineral to the quartz.

Having fixed our microscope in the manner above described, viz. with a quartz wedge inserted in the *eye-piece* at an angle of 45° to the plane of polarization, let us examine a second quartz wedge placed on the stage of the microscope in a position at right angles to the axis of the wedge in the eye-piece. In this position the velocity of the extraordinary ray is retarded in one of the two plates of quartz and accelerated in the other; and, at the point where the velocity of the extraordinary ray, on emergence from the upper quartz wedge, becomes the same as that of the ordinary ray, there is no double-refraction and a dark line appears.

If we examine the thin edge of the quartz on the stage of the microscope with the wedge in the eye-piece, the black line will be seen near the thin edge of the analyzing wedge, with spectra of the 1st, 2nd, 3rd, and higher orders rising in succession beyond it towards the thick end of the wedge. If we allow the analyzing quartz wedge in the eye-piece to remain stationary, and move the wedge on the stage of the microscope so that thicker and thicker portions of the quartz are successively brought within the range of

[1] The wedge should be a tolerably flat one so as to give a wide spread of colour.

vision, we shall find that the black line, above alluded to, moves gradually along the analyzing wedge from its thin towards its thick end, and spectra (in inverse order) of the 1st, 2nd, 3rd, and higher orders of Newton's scale, come in between the black line and the thin end of the analyzing quartz wedge. These chromatic bands of colour, as they rise in the scale of Newton's orders, become fainter, and fainter, until at last the eye fails to detect them and the spectra merge into white light.

This experiment shows that, other things being equal, the distance of the black line from the thin end of the wedge is proportional to the thickness of the quartz on the stage of the microscope.

If we now substitute for the quartz on the stage of the microscope a wedge of calc spar cut in precisely the same way with reference to its optic axis as the quartz wedge is cut, and of the same thickness as the latter, and placed in such a position on the stage that the axis of greater elasticity of the calcite is parallel to the axis of less elasticity of the quartz, we shall find that the thick end of the analyzing quartz wedge is insufficient to make the dark line and the spectra visible when we examine even the thin edge of the calcite. Indeed, so much more powerful is the double-refraction of calcite than that of quartz, that even the thick ends of two ordinary quartz wedges, superposed one above the other in the eye-piece,[1] are insufficient for the purpose.

If for wedges we substitute flat slices of different minerals of uniform thickness cut at the same angle to the optic axis, but differing from each other in the intensity of their double-refraction, we shall find the distance of the dark line from the thin edge of the analyzing quartz wedge, and the *number* of chromatic bands that come in between it and the thin end of the wedge, depends upon the intensity of the double-refraction of the mineral under observation.

I find, in short, by noting the position of the dark line in the quartz wedge, and by observing the number of the chromatic bands that appear between it and the thin end of the wedge, that it is possible to estimate the comparative thickness of the slice, when we are dealing with slices of the same mineral; or the strength, or feebleness, of the double-refraction possessed by a mineral when we have several sections of the same mineral in a slice of rock prepared for the microscope.

The application of the above principle to the examination of thin slices of rocks is complicated by the fact that the sections of minerals contained in them vary not only in thickness (for few slices, microscopically considered, are exactly equal to each other in thickness), but also in the angle to an optic axis at which they are sliced.

This difficulty, however, must be faced, for it is one that is not peculiar to the method described in these pages, but is common to *all* methods of estimating the double-refraction of minerals scattered promiscuously in rock-sections.

[1] The eye-piece of my microscope is furnished with two slots, one above the other, so I can either use two wedges at once or combine one wedge with an eye-piece micrometer.

When a mineral contained in one slice has to be compared with a mineral in another slice, we must, if we desire to be exact, measure the thickness of our slices, and take the disturbing element of the difference of their thickness into consideration. But for the rough and ready mode of estimating double-refraction now under description I have not found this necessary. Rock-sections prepared by a skilful lapidary—especially if we compare slices of rocks of the same class [1]—do not differ greatly in thickness; and if we always employ the same lapidary, we shall not go far wrong if we assume that our slices are, for the purpose in hand, of fairly equal thickness.

The difficulty connected with the fact that slices of rocks for microscopic study are made promiscuously without reference to the orientation of individual minerals, and that the sections of the latter are consequently cut at varying angles to their optic axes, may to a great extent be overcome by selecting for examination those crystals that display the brightest colours under crossed Nicols; for the sections that polarize brilliantly are presumably those made approximately parallel to an optic axis.

Notwithstanding the difficulties alluded to above, the quartz wedge is a delicate, as well as handy instrument, of great value in the practical determination of the minerals met with in rock-sections. It enables one, for instance, to separate at a glance such minerals as rutile, dolomite, calcite, sphene, anatase and zircon, from all others likely to be met with. It will enable us to detect even a speck of granular calcite of microscopic size imbedded in another mineral. The double-refraction of the above minerals is so powerful that when they are tested in the way above described, the dark line [2] does not come into view until the thick end of the wedge begins to pass over them, and the spectra, instead of being of normal width and distance apart, are narrow and crowded together. The character of these narrow and crowded spectra is so remarkable that an observer who has once seen them can never mistake them for those of a mineral possessing a less intense double-refraction.

So powerful is the double-refraction of rutile, calcite, and sphene, that I sometimes find it necessary to employ two quartz wedges, one above the other, in order to bring the spectra within the range of vision. Occasionally the mass of a crystal resists even the double wedge, and the spectra can only be seen in portions of the crystal, where, owing to its brittleness and liability to fray in the process of grinding, or from its edges overlapping other minerals, specially thin sections are exposed to view.

Minerals of feeble double-refraction, on the other hand, may be separated from those of strong, or of even average double-refraction, with equal confidence. If we examine such minerals as chlorite, nepheline, and apatite, we find that the dark line, described above, either appears *on the very edge* of the quartz wedge, or is just

[1] Basalts, for example, are usually sliced thinner than granites.

[2] When testing for double-refraction the stage must be revolved until the dark line appears in the mineral under examination. The azimuth in which this appears affords another valuable means of distinguishing between different species.

beyond the range of vision. In the latter case I call in the aid of the $\frac{1}{4}$ undulation plate: on inserting this above the object-glass, the spectra seen in the quartz wedge are shifted up the wedge towards its thick end, and the dark line previously beyond the range of vision is brought on to the edge of the wedge.

In the case of the above-mentioned minerals possessing very feeble double-refraction, the dark line appears, as just stated, at the *very edge* of the quartz wedge. In the case of sanidine, orthoclase, and other minerals of equally weak[1] double-refraction, the dark line appears *clear* of the edge of the wedge, but no chromatic band comes in between it and the edge. As we examine minerals of higher and higher double-refraction, we shall find the position of the dark line is more and more shifted towards the thick end of the wedge, and more and more chromatic bands come in between it and the thin end of the wedge.

Thus, to give a few examples drawn from my own experience of slices prepared by different lapidaries which are *not* all of equal thickness, I find that quartz in such sections rarely exhibits more than one and never more than two chromatic bands bētween the dark line and the edge of the wedge; whilst such minerals as muscovite, olivine, and actinolite, commonly present three, and not unfrequently as many as five such bands.

We have here, then, a means not only of comparing sections of minerals of equal thickness in the same slide, but sections of crystals in different slides, and we have a standard by which we may estimate the strength of their double-refraction. A mineral of strong double-refraction sliced at so high an angle to an optic axis as to approximate a plane normal to that axis will, of course, exhibit little or no double-refraction, and in the phenomena it presents will resemble a mineral of feeble double-refraction sliced approximately parallel to an optic axis; but a mineral of weak double-refraction can never exhibit the phenomena characteristic of one of strong double-refraction. When therefore, on testing a mineral with the quartz wedge, we find two, three, or five, chromatic bands appear between the dark line and the edge of the wedge, we know for certain that the mineral possesses stronger double-refraction than those minerals which never, in slices of normal thickness, present to our view more than *one* such chromatic band.

Even in the case of minerals of strong double-refraction sliced approximately normal to an optic axis, we gain something by examining them with the quartz wedge, for we learn from the position of the dark line[2] that the section is one either approximately normal to an optic axis, or is one of a mineral of feeble double refraction. If the former is the case, the mineral will exhibit characteristic appearances when examined in converging polarized light. If, on the contrary, it does not show any phenomena capable

[1] I use the word *weak* to indicate a slightly higher double-refraction than *feeble*. Thus, $\gamma - \alpha$ for chlorite is 0·001, but for sanidine is 0·008.

[2] The dark line will not appear in any azimuth in a section *quite* normal to an optic axis.

of interpretation when examined in the usual way with converging polarized light, we know that we have before us not an axial section, but a mineral of weak double-refraction sliced in another direction.

In cases where a mineral is of such microscopic size as to be less in diameter than the width of one of the chromatic bands exhibited by it, we can still easily count the number of chromatic bands that come in between the dark line and the thin edge of the wedge, if we confine our observations to one colour (red I find the most convenient), and, as we move the wedge forward over the mineral, count the number of times it assumes that colour before extinction takes place on the micro-crystal entering the dark line or region of no double-refraction.

In the examination of pounded fragments of minerals with the aid of a quartz wedge we must carefully consider the element of thickness, and we must confine our observations to flat surfaces parallel to the plane of the glass slide.

As an illustration of the close approach to accuracy that may be obtained by the use of the quartz wedge in the way described above, I may mention the following example. As Rosenbusch does not give the value of $\gamma - a$ for sphene in his *Microskopische Physiographie*, I recently wrote to inquire of a friend whether he could give me the required information, and I expressed at the same time my conviction that the double-refraction of sphene was, in intensity, somewhere between that of zircon and calcite. It turned out that the refractive indices of sphene have been worked out by M. Lévy and Lacroix, and are given in their book *Les Minéraux des Roches* just published. $(\gamma - a)$ or $(n_g - n_p) = 0{\cdot}121$. So that sphene really occupies the position I had assigned to it on the evidence afforded by the rough and ready use of the quartz wedge; the values of $\gamma - a$ for the three minerals being: calcite, 0·172 (Rosenbusch); sphene, 0·121 (M. Lévy); and zircon, 0·060 (Rosenbusch).

VI.—On a Remarkable Dyke in the Serpentine of the Lizard.

By Alex. Somervail.

THE dyke in question occurs at the extreme north end of Pentreath Beach, which is about a quarter of a mile to the south-east of Kynance Cove.

The dyke forms a portion of the "granulitic group" of Prof. Bonney, which is now known to be of igneous origin, and consists of banded gneissic rocks, some of which are like a granite, other portions like a diorite, the latter always more or less porphyritic.

This rather complex rock is here, as in many other localities, thrust through the serpentine, but, in this particular instance, it exhibits more remarkable features than any other dyke known to me in the Lizard area.

The dyke forms the central part of a small chine or gully. It rises from the shore to the top of the cliff, which is about 150 feet in height, and can easily be followed throughout its entire upward course, as the cliff here is not very precipitous. The decomposition

of the dyke along with that of the serpentine on either side of it being the cause of the gully.

From the main trunk of the dyke near its base a number of branches or veins are sent off which traverse the serpentine more in a lateral and diagonal direction than a vertical one, as does the parent mass.

These processes when taken together display a wonderful variety of rocks, most of which are to be found in the main dyke. These rocks in their extremes vary from a dull-looking trap, which many would term a dolerite, to a dark lustrous diorite, full of sparkling hornblende, then a greyish and also a reddish granite, followed by milk-white quartz, also masses of flesh-coloured felspar, with large plates of biotite, as well as some intermediate varieties of these rocks. At a height of about 60 feet from the beach, in the main dyke on the north side of the gully, the diorite, granite, etc., are well mingled together, and other alternations are found at other portions, as well as in the branches where the dull-looking trap occurs.

The inference to be drawn from these facts is, I think, that all the minerals and rocks mentioned have been differentiated out of the same magma during the cooling process, the ordinary selective law of chemical affinity separating the basic from the acidic types.

The lesson to be derived from this dyke also seems to me to have a very important bearing on the other rocks of the same area.

De la Beche, followed by Prof. Bonney, regards the schists, serpentine, gabbro and the granitic veins as belonging to widely separated intervals of geological time. When these are viewed in their massive relations to each other, there seems much to support this view, an opinion in which I also at one time partially shared; but repeated examinations have shown me that certain relations which held good in one district were very obscure, or flatly contradicted, in another. In fine, the whole of these rocks (schists included) really seem more or less to interlace each other, and to be the product of one great period of eruption, if not the product of the same magma, heterogeneous or complex it may have been, rendered still more so, by cooling under different conditions.

Among other proofs of this, there is what seems to me a very decided transition of the various Lizard rocks into each other, not promiscuously perhaps, but by way of the hornblende into the serpentine, also the hornblende into the gabbro. In the former case, as in the intermediate varieties of these rocks forming the islands and coast of Kynance Cove, and of many other localities. In the latter case, as in the curious mingling of the gabbro with the "granulitic" portion of the hornblende so often forming a gabbro-hornblende-schist, as at the Balk and Lean Water.

The lesson of the dyke would yet further seem to teach us that however much subsequent dynamic action may have affected these Lizard rocks, their strongly contrasted varieties are much less due to this cause, even when combined with any chemical change which might arise therefrom, than to a highly heterogeneous magma, inter-

mittent in its outbursts, and cooling under widely different conditions, affecting the attraction or repulsion of its mineral constituents. The whole of these Lizard rocks bear the impress of this later mechanical and chemical change, but the broader features due to these original and subsequent causes should, I think, be distinctly separated and clearly recognized.

VII.—Preliminary Notes on some Occurrences of Tachylyte in Mull.

By Percy F. Kendall,
Assistant Lecturer on Geology at the Owens College.

THE following notes have been compiled in order that, pending the publication of the results of microscopic and chemical examination of the specimens collected, geologists visiting the island may have an accurate localization of the dykes and intrusive sheets bearing glassy selvages observed by the writer and Mr. J. Lomas, A.N.S.S., during a recent visit to Mull. The list includes, for the sake of completeness, three occurrences of tachylyte which have already been described, viz.:—Sorne and Gribun[1] and Ardtun.[2]

The writer has not visited Sorne, but found the tachylyte at Ardtun, and re-discovered that at Gribun, in May, 1887. The last two exhibited certain peculiarities which appear to have hitherto escaped notice, and will be alluded to in the sequel. It is probable that some of the examples will prove upon examination to be more acid than the true tachylytes.

In the table which follows, the word "country" is employed as a convenient term to indicate the rock through which a dyke or intrusive sheet passes, or, briefly, in the miner's sense.

Many dykes which once possessed glassy selvages have undergone a process of decomposition, which, while removing all trace of actual glass, yet, leaves characteristic appearances which are quite unmistakable, though difficult to describe. Among the 200 or 300 dykes examined in Mull, a very large proportion are in this condition.

The tachylyte is occasionally very local in its distribution, and may be present only in small, widely-separated patches.

As a general rule it is thickest on the outsides of the curves of sinuous dykes (*e.g.* A. 12).

The character of the "country" appears to have influenced the formation of glassy selvages, hard and compact rock being a better conductor of heat than loose decomposed or vesicular material has favoured their production. This has been observed in numerous instances of which A. 12 may be taken as the most conclusive. The dyke can be traced across the junction of a sheet of compact basalt with an underlying highly vesicular rock, and thence on into the compact rock again, and it can be seen that in the compact rock the tachylyte is $\frac{1}{4}$ in. thick, while in the softer rock it is reduced to a mere film. Occasionally, in following up a dyke the tachylyte

[1] Judd and Cole, Q.J.G.S., vol. xxxix. [2] Cole, Q.J.G.S., vol. xliv.

No.	Position.	Bearing (Magnetic).	Character of Dyke or Sheet.	Character of Tachylyte.	Character of "Country."	Remarks.
S. 1.	About 200 yards S.W. of Pier at Salen, Mull.		Intrusive sheet, ? thickness. Vesicular in median part.	Greenish to black. About ¼ in. thick.	Mostly compact, but varying with position of sheet.	The sheet is quarried for road metal near the road.
S. 2.	Port Mòr, Ardmòr, Salen. Behind Port Mòr House.	General.*	Dyke 4 feet thick, fine-grained pyritous basalt.	⅛-¼ in. thick. Black. Soft (?).	Compact ? felsite.	The specimens are as a rule very soft, and therefore I mark this as doubtful.
S. 3.	Port Bean near "y" of "Salen Bay" on 1 in. map.	N. 4° W.	Small string parallel to a large dyke.	A thin and local film. Black and lustrous.	Compact.	
S. 4.	About 10 yards E. of old cottage, Rudh 'a Ghuail, Salen.	Nearly due N.	Dyke 3 ft. 6 in. wide. Fine transverse columns.	⅛ in. thick. Greenish. Soft (?).	Compact.	
S. 5.	20 yards E. of S. 4.	N. 18° W.	Dyke about 5ft. wide. Sinuous with strong rhomboidal jointing.	Thin, with dull lustre, and very local.	Highly amygdaloidal.	There are layers of infiltration matter between selvage and "country."
S. 6.	E. of Salen Pier—runs under eastern corner of waiting room.	Runs between Beinn na h'Uaigh and Beinn Chreagach.	Dyke with many parallel strings.	⅛ in. thick, but thicker in angles. Black and lustrous.	Compact, with porphyritic felspars.	
S. 7.	7 feet E. of S. 5, of which it is probably a branch connected by a small bridge-like intrusive sheet.	Same as S. 5.	Dyke 2 ft. 5 in. wide.	⅛ in. thick. Black to green.	Same as S. 5.	There are clear traces of an intrusive sheet adhering to the "country" between S. 5. and S. 7.
K. 1.	Loch na Keal, western end of first field W. of Kellon Wood and on shore opposite.	*Dip* 20° to W.	Intrusive sheet of columnar basalt 18 in. to 2 feet thick with tachylyte top and bottom.	Black, lustrous, upwards of ¼ in. thick.	Compact amygdaloidal basalt.	The columns are used as a parapet to road beside Kellon Wood.
K. 2.	N. side of Loch na Keal to W. of Sgeir Maldaig and to E. of "16."	N. 17° W.	Dyke 5 ft. 9 in. wide.	Black, lustrous. ¼ in. thick.	Amygdaloidal basalt.	
K. 3.	Intersected by K. 2.	N. 20° W.	Dyke 14 in. wide.	Black, lustrous.	,,	
K. 4.	30 yards E. of K. 2.	Parallel to K 2.	Dyke 8 in. wide.	,,	,,	
L.P.	Where telegraph wires cross road 300 yards beyond second milestone from Tobermory to Loch Peallach.	Parallel to Sound of Mull.	Dyke of magma basalt with pyrites in joint-planes. Columnar and platy.	Black. Perfect vitreous lustre.	,,	Near the road the "country" is rotten, and the tachylyte thin and soft; but further in the "country" is hard and the tachylyte good.

T. 1.	Tobermory Burn—below top fall, just opposite a bye-road.	N. 7° W.	Dyke with columnar jointing. Magma basalt with a little augite.	Black, lustrous.	Compact basalt.	Found by Butler & Kendall, May 1887. A small kernel of tachylyte occurred within the dyke about 6 in. from selvage.
T. 2.	About 10 yards below T. 1.	N. 5° W.	Dyke about 8 in. wide.	Thin and local.	,,	
T. 3.	About 2 yards below T. 2.	N. 5° W.	Dyke 9 in. wide.	,,	,,	
Rn. G.	Rudha nan Gael. Cliff just behind Coastguard Station.		Dyke 3 ft. 6 in. wide. Magma basalt with porphyritic labradorite.	Lustrous, black. Nearly ¼ in. thick.	Hard amygdaloidal basalt.	Found by Butler & Kendall, May 1887. Block on the shore fallen from dyke visible in cliff.
E. 1.	W. side of Erray Burn (between lighthouse and Bloody Bay).	Parallel with Sound of Mull.	Dyke about 3 ft. wide. Coarse grained basalt with minute amygdules and eroded labradorite crystals 2 in. long.	Lustrous, black. About ¼ in. thick.	Rather decomposed columnar basalt.	Found by Butler & Kendall, May 1887.
E. 2.	E. side of Erray Burn.	,,	Dyke of fine-grained basalt 8 feet wide.	Much decomposed. Black, with resinous lustre. Firmly adherent to dyke.	,,	
G. A.	Glen Aros, ¼ mile above bridge and 100 yards E. of cutting showing spheroidally weathered basalt.	N. 5° W.	Dyke of pale green rock with minute amygdules and some large mica crystals. 26 in. wide.	Very dark green. 2¼ in. thick, passing into spherulitic structure internally.	Basalt dyke in spheroidally weathered basalt.	This appears to be a case of "dyke-in-dyke."
A. B.	Aros Bridge, just behind 1st house on road to Tobermory.	N. 2° W.	Dyke of porphyritic basalt, 7 feet wide. Much broken up.	Very thin and local. Black and lustrous.		
A. 1.	Immediately behind Aros Hotel and passing E. window.	N. 20° W.	Dyke of magma basalt, 5 feet thick.	Greenish to jet black. ½ in. thick.	Compact basalt.	The *average* direction would probably prove about N. 5° W.
A. 2.	Seaward side of Aros Hotel.	Towards Beinn Chreagach.	Sinuous dyke 20 in. wide. In places very amygdaloidal.	Black and lustrous, coating the dyke in broad patches where the "country" is worn away.	Coarse amygdaloidal basalt.	
A. 3.	Aros Hotel just N. of creek where boats are drawn up.	N.W.	Many small string-dykes, parallel to a large one. The strings are about 1 in. wide and are vesicular down middle.	Very thin.	Coarse basalt.	The strings contain large felspar crystals.
A. 4.	Shore N. of Aros Hotel, 70 yards S. of 2nd wall.	N. 37½° W. Strikes large island in Sound.	Dyke 15 in. thick.	Thin, lustrous.		
A. 5.	At 2nd wall N. of Aros Hotel.	N. 15° W.	Dyke 4 feet wide. Porphyritic basalt.	Black and lustrous. Thin, local.	Compact basalt.	The dyke runs like a wall for a long distance. The tachylyte is best seen on E. side a few yards from the wall.

* Probably about N. 5° W.

No.	Position.	Bearing (Magnetic).	Character of Dyke or Sheet.	Character of Tachylyte.	Character of "Country."	Remarks.
A. 6.	200 yards N. of A. 5. and 50 yards N. of a wall with wire fence.	N. 26° W.	Dyke with many branches to the S. 8 feet wide at Max.	Black, lustrous. On one branch which thins to nothing, it occurs on both ends of columns.	Compact basalt, much shattered.	
A. 7.	A little N. and seaward of A. 6.	N. 25° W.	Dyke 4 feet wide of coarse vesicular basalt. Breaks to Northward into 8 branches.	Very thin.	"	
A. 8.	Nearly parallel to A. 9, and displaces it by crossing.	Strikes for Beinn Bhearnach.	Dyke 4 feet wide. Fine-grained basalt weathering sharply.	Best seen at contact with A. 9. Thick.	Compact basalt.	
A. 9.	Allt na Criche; crosses 1st fence N. of cottage.	N. 35° W.	Dyke 8 feet thick. Weathers into rounded masses. Coarser than A. 8.	Bright lustre.	Compact amygdaloidal basalt.	This dyke can be traced to the road from Salen to Tobermory, about 100 yds. S. of milestone "Sal. 3."
A. 10.	Crosses next stone wall to N. of A. 9.	N. 10° W.	Dyke 2 feet wide.	Black, lustrous. Strings of tachylyte penetrate the "country."	Very tough amygdaloidal basalt.	
A. 11.	Between A. 10 and next wire fence to N.	N. 5° W.	Dyke 8 feet wide. Basalt with very large felspars.	Black, lustrous.	Rotten amygdaloidal basalt.	
A. 12.	Strikes shore a few yards beyond wire fence N. of A. 11.	N. 23° W.	Dyke 3 ft. 6 in. wide with parallel composed entirely of tachylyte.	Black, lustrous, ½ in. thick. Thickest on convex side of bends in dyke.	Compact, somewhat soft basalt, resting on decomposed, highly amygdaloidal basalt.	The wire fence alluded to runs up to road 15 yards from milestone "Sal. 3." Where the dyke is in contact with the amygdaloidal rock, the tachylyte is very thin.
A. 13.	30 yards N. of A. 12.	Parallel to A. 12.	Dyke 1 foot wide thinning right out to southward.	Greenish to black. Lustrous.	Compact amygdaloidal basalt.	*Note.*—The dykes A. 1 to A. 13 are given in regular sequence along the shore from S. to N.
A. 14.	N. shore of Port nam Buitsichean 20 yards W. of bye road to Tobermory.	N. 25° W.	Dyke 5 feet wide. Bifurcates and re-unites. Very coarse and vesicular in median portion.	Thin, black, and lustrous.	Coarse compact amygdaloidal basalt, with lustrous brown crystals.	
A. 15.	Apparently cut by A. 14 to seaward.		Dyke 3 feet wide.	Thin.	"	
A. X.	On road from Salen to Tobermory beyond second milestone and 20 yards from turning to Ledmore Loch Frisa.	N. 15° W.	Dyke 5 feet wide.	Black, lustrous.		The specimens obtained *in situ* were poor though unmistakable, but on the wall intersecting the dyke were fine examples.
T.R. 1.	On same road where the 400 yard line crosses between 4th and 5th milestone from	N. 15° W.	Dyke.	Black, lustrous; about ¼ in. thick.		

T.R. 2.	On same road, a little nearer to Tobermory than 3rd milestone.	N. 20° W.	Dyke. Contains large felspars like those in A. 11 and E.B. 1.	½ in. thick. Greenish. Includes large felspars.	Compact basalt.	Dyke and "country" are worked for road-metal.
T.R. 3.	On same road, a few yards from gate "Upper Druimfin."	N. 5° W.	Dyke 4 feet wide.	Thin.	Very compact and adherent to dyke.	
K.R. 1.	On summit of road from Salen to Killichronan.		Intrusive sheet exposed from some distance in roadside. Marked platy jointing.	Black to greenish. Very local.	Hard and compact.	The specimens were found after repeated searches close to the intersection of a large dyke. We were led to re-examine by finding a block with tachylyte on the Survey cairn on the level stretch of road nearer to Salen.
K.R. 2.	A few yards W. of K.R. 1, where intrusive sheet dips under talus, and before its reappearance to W.	General bearing.	Small dyke 2-5 inch wide.	Local. Greenish to black.	Compact basalt.	
C.M. 1.	Creag Mhòr, S. side of Loch na Keal. About letter "r" in "Creag" 1 in. map.		Probably from intrusive sheet about 1 foot thick. Fine-grained basalt with iron pyrites. Columnar.	Black, lustrous.	Compact, coarse-grained basalt.	A dyke and at the least six intrusive sheets are visible in the cliffs. The specimens were from fallen blocks.
C.M. 2.	Fallen block at 1st bridge from Creag Mhòr towards Gribun.			Black, lustrous.	"	
G.	Pass of Gribun about letter "a" in "Balmeanach" on 1 in. map, and 100 yards S. of gate.	? about N. 40° W.	Dyke 3-8 in. wide. Bifurcates and re-unites.	Black and highly lustrous. Max. 1 in. thick. Runs into the vesicles in "country."	Rotten, pulverulent, and amygdaloidal, but for a foot on each side of the dyke very hard and compact.	Described by Judd and Cole, Q.J.G.S. vol. xxxix. Rediscovered by Butler and Kendall, May, 1887.
T.	Torrens, Loch Scridain.			Black and lustrous.		The specimen was found by Mr. F.H. Butler, May, 1887, upon a wall to W. of Torrens. Time would not permit of its being traced to its source.
A.B.	Ardtùn Brae.		Intrusive sheet.	Black, highly lustrous. Max. 5 in. thick. Runs down between columns of underlying basalt for a distance of 4 feet.	To N. compact non-vesicular, and to S. amygdaloidal basalt.	Described by Cole, Q.J.G.S. vol. xliv. Discovered independently by Duke of Argyll (?), Mr. Koch, Mr. Cole, and Butler and Kendall (May, 1887).
B.C.	Summit of Beinn Chreagach, near S. side.		Intrusive sheet 10 in. thick.	Greenish. Dull lustre.	Very coarse gabbro.	The rock has rather the appearance of an intermediate rock.
	Sorne, 3 miles N.W. of Tobermory.		Dyke.	¼ inch thick.		Described by Judd & Cole, Q.J.G.S. *loc. cit.*

gives place to a black or greenish substance having a hardness of about 2.

Several cases have been noted in which small strings have been given off consisting wholly of tachylyte, for example strings descend from the Ardtun intrusive sheet between the colums of the basalt "country" to a distance of, at the least, four feet.

A good test for intrusive sheets when the stratigraphical evidence is inconclusive has long been a desideratum, and it may be that certain peculiarities in those observed in Mull may prove really diagnostic when a sufficient number of examples have been examined to justify generalisation.

The Ardmòr intrusive sheet (S. 1) was recognized as such in the first instance by the extraordinary sharpness of the plate-like columns and subsequently the determination was confirmed by the discovery of the tachylyte selvages. This sheet is amygdaloidal *in the middle* and the same peculiarity is presented by other intrusive sheets, and also by many dykes (*e.g.* G. A.) in Mull, while, as is well known, lava-streams are vesicular top and bottom.

In conclusion, the writer desires to express his conviction that, when Mull comes to be fully surveyed, dykes with tachylyte selvages will be numbered by hundreds, or, it may be, even by thousands.

Note by Bernard Hobson, Esq., B.Sc.—On the coast, between tide-marks, to East of the "principal ravine" of Mr. Starkie Gardner, at Ard Tun, are two intrusive sheets, each about one foot thick, one above the other, with only 2 or 3 inches between them. They are intruded into the basalt, and each sheet bears a thick selvage of tachylyte both above and below, the mass of the sheet being characterized by large spherulites, clearly visible to the naked eye, especially when the rock is wet. The sheets are irregularly columnar and their surfaces where exposed by erosion of the "country," present a striking appearance owing to their brilliant glassy blackness.

VIII.—Notes on the "Monian System" of Professor Blake.

By Ch. Callaway, D.Sc., F.G.S.

As Professor Blake, in his elaborate paper in the Quarterly Journal of the Geological Society for August last, makes frequent reference to my work in Anglesey, I may perhaps be permitted a brief comment. I do not intend to enter upon an elaborate controversy, since I prefer, now that the two views of the district have been published, that those interested in the matter should visit the ground, and judge for themselves. Nevertheless, it is well that the salient points of agreement and difference between the two readings should be placed in a clear light.

On the fundamental question—the Archæan age of the bulk of the Anglesey crystallines and altered slates—Prof. Blake is at one with Dr. Hicks, Prof. Bonney, and myself; but he differs from those geologists who place a part of our Archæan in the Ordovician, and

from Sir A. C. Ramsay, who referred the whole to post-Archæan times. The chief difference between Prof. Blake and myself is that whereas I subdivide the Archæans of Anglesey into two groups, which, to avoid theory, I simply described as *Gneissic* and *Slaty*; he desires to lump them together as one system called *Monian*. This divergence of opinion is not very serious. If stratigraphical links between two formations can be detected, it may (and it may not) be desirable to give them one name. The question is, Are Prof. Blake's links strong enough?

Before answering this query, I should like to indicate one or two additional points on which I am happy to express acquiescence with Prof. Blake. When I first studied the rocks of Anglesey, nearly ten years ago, I held the current views on metamorphism. Most geologists of that day believed that mineral-banding in schists generally followed an original sedimentation, and the evidence then available tended to support that view. Accordingly, when I saw granite interbanded with schists in parallel beds, I followed Dr. Hicks and Prof. Bonney in concluding that this granite was of metamorphic origin. We have since then learned much of the wonderful effects produced by pressure. I have accordingly studied some of my former sections in the light of the new theories, and have adopted a different interpretation of some of the old facts. I hold that the granitoid mass in the centre of the island is truly igneous, and sends apophyses into the adjacent schists; also that some of these schists themselves are igneous rocks, diorite and felsite, which have been metamorphosed by mechanical and chemical energies. It will be seen that I thus go beyond Prof. Blake himself, who, as I understand him, assigns a plutonic igneous origin only to the granite and the modified diorite. My views were given in outline to the British Association in 1887, before I knew that Prof. Blake had come to similar conclusions.

How far do the new theories affect my old work? Simply thus: my time-succession of the Older Archæans becomes a mineral succession. The mapping and sections remain substantially the same, but the element of time must be transferred from a supposed order in deposit to the order in which the igneous masses were extruded and to the period or periods of their metamorphism.

My descriptions of the Newer Archæan rocks are in the main accepted by Prof. Blake; but he has added many observations made in districts not studied by me. These, if confirmed, will prove to be of much interest.

A little more care would have saved Prof. Blake some trouble. He elaborately attempts to refute my (supposed) opinion that the rocks of Paris Mountain are of Archæan age. It is true that in my map I placed this mass in the Archæan, because it was necessary to put it somewhere, and the evidence seemed to me to turn a little in favour of the Archæan view; but in the text (Quart. Journ. Geol. Soc. May, 1881, pp. 222 and 224), I expressly declined to assign any age to the rocks, and to that scepticism I still adhere.

To return to our main question: Is there only one Archæan

system in Anglesey? In arguing for two groups, I assigned some importance to the evidence of included fragments. Prof. Bonney (*supra*, p. 235) states that the Llanfechell Grit (Newer Archæan) contains "detrital materials almost certainly derived from the older gneissic and schist rocks of this part of North Wales." Again, in the Quarterly Journal for 1884, p. 576, I contended that the basement Palæozoics near Tywyn contained fragments of slaty rock, and that a mass of the same slate *in situ* included rounded pieces of the adjacent granite. Prof. Bonney, after microscopic examination, unhesitatingly confirmed my identifications. Prof. Blake, however, contests both points. He says that none of the fragments in the Llanfechell Grit are "indubitably schists." Prof. Bonney, at my desire, has re-examined the rock, and thus writes:—

"My description is accurate. There are several fragments of a very fine-grained schist consisting of quartz and a flaky green mineral, which is either chlorite or an altered biotite, so far as I can make it out. These much resemble some of the finer-grained schists of Anglesey in my collection. Of course, in some crystalline schists one cannot say how much of the structure may be due to mineral segregation, or to veining subsequently modified; but in the ordinary sense of the words these are bits, not of vein substance, but of schist. Probably Prof. Blake was unlucky with his specimen." In reference to the last suggestion, I may say that both professors have studied *the same* slide.

The slate near Tywyn is regarded by Prof. Blake as a "diabase." The slides of this slate originally described by Prof. Bonney have been again examined by him. This is what he says about them:—"My descriptions are accurate. There must be some misunderstanding about the locality, for I cannot realize the possibility of such a mistake being made as to call this rock a diabase." Prof. Blake[1] appears to have no doubt that his "diabase" is the same as my "slate," and from his description I should think he was right; though his examination of the ground was so incomplete that he did not even find the conglomerate and grit[2] which rest on the eastern side of the granite axis. If then Prof. Blake has rightly identified his "diabase" with my "slate," we are driven to make a choice, on the microscopic question, between him and Prof. Bonney. Prof. Blake will forgive me if I prefer Prof. Bonney's opinion to his.

Having thus disposed of the argument from included fragments, Prof. Blake attempts to prove that there is a passage between my lower and upper groups. It would take a paper of many pages to discuss this point. Whatever there may be in spots I have not visited, I am bound to say that in those districts known to me Prof. Blake's efforts to connect the gneissic rocks with the slaty appear

[1] In a note to p. 483, Prof. Blake has "little doubt" that I sent to Prof. Bonney fragments included in the Palæozoic in mistake for specimens of the rock *in situ*! I make no comment on this suggestion, as I am unwilling to believe it was seriously intended.

[2] Several specimens were described in my paper (Nos. 124, 125, 126).

to me quite unsuccessful. I will give two examples. In the Llangefni "syncline," Prof. Blake wishes to construct a sequence from the grey gneiss up to the Llangefni conglomerates. He admits a fault somewhere to the east of the gneiss; but says that "the throw of the fault *may*[1] not be great, and the lowest rocks exposed (to the east of the fault) *may* not be far above the grey gneiss." Again: the rocks to the east of the fault pass *downwards* into the Llangefni[2] conglomerate; but Prof. Blake comes to the conclusion that this order is inverted, and he offers as his main proof the proposition that if there is no inversion, the order is different from that which obtains elsewhere. But I am not at all satisfied what is the normal succession, and I do not think that Prof. Blake has established it. In this district, then, Prof. Blake's demonstration rests upon two hypotheses and an unproved inversion.

Again, in the area south-west of Mynydd Llwydiarth, our author is "led to see there is an undisturbed succession" between my Gneissic and Slaty groups, although he admits that the ground is "broken." It is broken, with a vengeance, and any attempt to mend it into "an undisturbed succession" is doubtful in the extreme.

If Prof. Blake's "Monian System" is of any value, it must be applicable to other regions. Its author applies it to Shropshire. The Longmyndian[3] group is referred to "Upper Monian"; the Uriconian and Malvernian are lumped together as "Middle Monian." The Longmyndian is placed in the "Upper Monian," because it is correlated with the Bray Head Series (elsewhere affirmed to be Upper Monian) by its fossils. This fossil evidence is entirely new to me. When we have seen it, we shall be able to judge of its value. As the Longmyndian is largely derived by denudation from the Uriconian, there must be a considerable gap between the two. Again, there must be a marked break between the Uriconian and the Malvernian, for the latter underwent its metamorphic change (by whatever means) before the Uriconian period, and its dominant strike is discordant to that of the newer series. And if the Malvernian is only "Middle Monian," where shall the "Lower Monian" be found? But to those who know the Shropshire rocks, the attempted correlations will appear so unsubstantial that any argument I can urge will almost seem like beating the air.

If the Longmyndian is Archæan, Shropshire and Malvern will furnish us with a threefold subdivision of the Archæan rocks, the Malvernian, the Uriconian, and the Longmyndian; and I submit that these will make far better types than the battered fragments of Archæan rock in Anglesey. If the Uriconian is Pebidian, of course Dr. Hicks's term has priority.

[1] The italics are mine.

[2] Prof. Blake calls this an "agglomerate." As the contained fragments, which are rounded, are mainly quartzite, with grits and hornstone in smaller proportion, I do not see the applicability of the term.

[3] I used this name for the Longmynd series in a paper contributed to the Transactions of the Shropshire Archæological Society in 1887, on the ground that its Cambrian age was doubtful.

NOTICES OF MEMOIRS.

I.—Note on the Occurrence of Leucite at Etna.[1] By H. J. Johnston-Lavis, M.D., F.G.S.

SOME years since, whilst on a visit to Etna, my attention was drawn to some superficially placed tuffs of a chocolate to a coffee-brown colour. In these tuffs, near the Casa del Bosco, are observable included pieces of scoriaceous lava which to the naked eye are evidently leucitic; that mineral occurring in well-formed crystals attaining to some millimetres in diameter, and brilliantly white as the result of fairly advanced kaolinization. In consequence of this change the rock is excessively friable, and, therefore, difficult to sectionize. A section of it, however, was exhibited at the meeting, and also two photo-micrographs therefrom. In these it will be seen that kaolinization has extended along the fracture planes of the leucites, whilst the beautifully formed pyroxene crystals are unaltered, and the triclinic felspars are fairly in a normal condition. The base is a microlitic net-work of felspar and pyroxene, together with beautifully minute cubes and octahedra of magnetite, rendering the substance intervening between the crystals almost opaque, even in thin sections. The pyroxene is often enveloped in a casing of leucite, as at Vesuvius, Roccamonfina, etc., confirming what I have asserted in other places, namely, that leucite is one of, if not the latest mineral to crystallize.

I regret that I have not the opportunity of investigating the question of the origin and age of this rock more completely, as on writing to my friend Prof. O. Silvestri, inquiring if leucite had yet been encountered at Etna, I received a categorical answer in the negative which, coming from such an authority, must be taken as conclusive as to the rarity of leucitic rocks being produced from Etna.

The discovery of this mineral at Etna is what one would have looked for, knowing as we do its wide distribution in nearly all the other late basic volcanoes of Italy.

II.—An Igneous Succession in Shropshire.[1] By W. W. Watts, M.A., F.G.S., Fellow of Sidney College, Cambridge.

THE author described the succession of igneous rocks in the Shelve and Corndon district of Shropshire. 1. There is a series of *andesitic* ashes interbedded at two principal horizons in the Ordovician sequence. These have a percentage of silica varying from 63–60. 2. Then come three sets of intrusive masses. *a. Andesites* (59–54 per cent. of silica); these are intruded into Ordovician rocks and never touch the Silurian of the district. *b. Dolerites* (49–47 per cent. of silica), which are post-Silurian in date. *c. Picrites* (40–34 per cent. of silica), of later date. There are undoubtedly rocks intermediate in age and composition, but it is difficult to be quite sure of this where the differences in composition are so slight. One,

[1] Read before Section C. (Geology) British Association, Bath, September, 1888.

however, the dolerite of Llanfawr, is a very basic dolerite, coming between the normal dolerites and picrites. In minerals a similar transition is to be noted. The andesites are rich in hypersthene, the dolerites rather richer in augite, while olivine and brown mica occur in the picrites. The author believed that the felspars became most basic in the more basic rocks, but he had not yet fully investigated this point. Another curious point was that the mineral aggregates in the glomero-porphyritic andesites are practically pieces of the ophitic dolerites. The determination of the specific gravities gave a similar sequence, the lighter rocks having been intruded last. Each of the irruptive rocks occurred in laccolites along the main anticline of the district, and also in the dykes and fault lines.

III.—On the Lower Carboniferous Rocks of Gloucestershire.[1]

By E. Wethered, F.G.S., F.C.S., F.R.M.S.

In Gloucestershire there are two Coal-fields, namely, that of Bristol and the Forest of Dean. The Carboniferous Limestone Series of Gloucestershire was long ago divided by Sir H. De La Beche as follows:

Upper Mixture of Sandstones.

	Clifton. Feet.	Forest of Dean. Feet.
Marls and Limestones	400	146
Central Portion...	1438	480
Lower Shales	500	165
	2338	791

The author has proposed some detailed alterations with regard to the Bristol Coal-field which are stated in the Quart. Journ. Geol. Soc. for 1888, p. 187, but the above divisions have been generally accepted under the terms Lower Limestone Shales, Carboniferous Limestone, and Upper Limestone Shales. Professor Hull has given a classification of the Carboniferous Series throughout the country (Quart. Journ. Geol. Soc. 1877), based on the various stages which occurred during the deposition of the rocks. The author supports the principle of that classification, and is of opinion that the Lower Carboniferous rocks of Gloucestershire might be correlated with the same formation in the North of England. If this could be done, it might be possible to adopt terms for the respective stages which would apply to the North and South of England, and thus avoid the complication of terms now in use.

The author then recited the stages which occur in the Carboniferous Limestone of Gloucestershire. Above the Old Red Conglomerate there appears a series of sandy beds which are best developed in the Forest of Dean. These consist of micaceous green shales and red, purple and yellow sandstones. Some are calciferous and readily effervesce when treated with acid. No fossils have been found, but quartz pebbles occur in some of the beds.

The strata just referred to pass up into limestone and shales, the

[1] Read before Section C. (Geology) British Association, Bath, September, 1888.

so-called Lower Limestone Shales. In the Forest of Dean the limestones are largely made up of the valves of Ostracoda, among which the following have been determined: *Kirkbya variabilis*, *K. plicata*, *Cytherella extuberata*, *Bythocypris sublunata*, and *Darwinula berniciana* (?). Among the other fossils which are numerous may be mentioned *Athyris Royssii*, *Rhynchonella pleurodon*, *Encrinites*, and *Polyzoa*. Among the latter the following have been determined: *Rhabdomeson gracile*, Phill., and *Fenestella tuberculocarinata*, Ether. jun. In the Lower Limestone Shales of the Bristol Coal-field Ostracoda are not so plentiful, though in some beds the valves of these small Crustacea are numerous. *Rhynchonella pleurodon*, *Athyris Royssii*, *Productus*, *Spirifera*, Crinoids, and Polyzoa occur. At Clifton the Lower Shales are followed by a Crinoidal Limestone known as the Black Rock, which is about 490 feet thick and is not represented in the Forest of Dean. The Black Rock series are followed by 70 feet of Dolomite, and then by about 100 feet of white oolitic limestone which the author regards as the true base of the Middle or Carboniferous Limestone. The author has grouped the Lower Limestone Shales with the Black Rock under the term Lower Limestones, and he considers the stage to occupy the horizon of the Tuedian and Calciferous series of the North of England and Scotland. As to the sandy beds which lie between the Old Red Conglomerate and Lower Limestone Shales, the author regards them as the equivalent of the lower portion of the Transitional series of Phillips and the Calciferous of Scotland. The true upper limits of the Old Red Sandstone should be drawn at the Old Red Conglomerate.

As to the Middle Limestone there can be no doubt that it is the equivalent of the Carboniferous Limestone as generally understood, a term which the author thinks objectionable, and he would term the whole series Carboniferous Limestone. The Middle Limestone is largely made up of *Foraminifera* and *Calcisphæra*, but Corals, Polyzoa, Crinoids, and shells occur, sometimes in quantity. In the Forest of Dean the Middle Limestone is extensively dolomitized.

Coming to the Upper Limestones; at Clifton it is difficult to draw the line at which the series should commence, as there is little alteration in the structure from that of the Middle Limestones. Corals are more numerous, coarse oolitic beds appear, and the beds become mixed with Millstone-grit. In the Forest of Dean the upper stage is well and clearly defined by two characteristic limestones known as 'Crease' and 'Whitehead.' The former of these has become partially crystallized, but in some beds shells of *Productus* are numerous, and also *Calcisphæræ*.

The Millstone-grit is about 900 feet thick in the Bristol Coal-field, and is a hard, slightly pink-coloured quartzite. In the Forest of Dean it is about 270 feet, and is a loose yellow, red and mottled sandstone made up of well-rounded grains of quartz. The lowest beds are argillaceous, and contain remains of *Lepidodendra*.

I.—Notes on the Geological History of the Recent Flora of Britain. By Clement Reid, F.G.S. [Annals of Botany, vol. ii. No. vi. August, 1888.]

We are glad to be able to direct attention to this important paper, which records the plants obtained in this country from Preglacial, Interglacial, and Postglacial deposits. By means of investigations, which Mr. Reid has for some years carried on with great assiduity, he hopes to show what plants are truly native, what variations of climate they show, and the geographical distribution of the living species in past times. In the meanwhile he publishes an account of the material at present obtained, and this it is hoped may stimulate others to pay attention to the subject of the geological history of the Recent flora.

The Preglacial deposits from which plants have been obtained, belong to the Cromer Forest-bed, which underlies all the Glacial deposits, and forms the highest portion of our Pliocene formation. The Interglacial deposits include beds which underlie Boulder-clay, but are newer than the Cromer Forest-bed, and with them is classed, for the sake of convenience, the bed with Arctic plants (discovered by Dr. Nathorst) that underlies the lowest Boulder-clay in Norfolk. The Postglacial group includes the "submerged forests," and contemporaneous upland deposits; raised marine deposits, like the Clyde beds; and beds with Arctic plants, lying directly above the latest Boulder-clay of the district. Only those species are included that date from a period previous to the Roman occupation.

The different localities from which Interglacial plants have been obtained are nearly all in Scotland, and the most interesting deposits are those found at Redhall and Hailes quarries, about three miles from Edinburgh, where a large collection of specimens has been obtained by Mr. James Bennie.

The following is a list of the species recorded by Mr. Reid:—

Species.	Pre-glacial.	Inter-glacial.	Post-glacial.
Thalictrum minus? Linn.	x		
——— *flavum*, Linn.	x		
Ranunculus aquatilis, Linn.	x	x	
——— *sceleratus*, Linn.	...	...	x
——— *flammula*, Linn.	...	x	x
——— *lingua*, Linn.	...	x	
——— *repens*, Linn.	x	x	x
Caltha palustris, Linn.	...	x	
Nuphar luteum, Linn.	x	...	x
Lychnis diurna, Sibth.	...	x	
——— *flos-cuculi*, Linn.	...	x	x
Stellaria aquatica, Scop.	x		
——— *media*? Linn.	...	x	
Oxalis acetosella, Linn.	...	x	
Prunus communis, Huds.	x		
——— *padus*, Linn.	...	x	x
Rubus idæus, Linn.	...	x	x
——— *fruticosus*, Linn.	x	x	
Potentilla tormentilla? Neck.	...	..	x
——— *comarum*, Linn.	...	x	

Species.	Pre-glacial.	Inter-glacial.	Post-glacial.
Poterium officinale, Hook.	x		
Hippuris vulgaris, Linn.	x	x	
Myriophyllum spicatum, Linn.	x	x	
Trapa natans, Linn.	x		
Apium nodiflorum, Reich.	...	x	
Carum carui, Linn.	...	x	
Œnanthe lachenalii, Gmelin.	x	...	x
Peucedanum palustre, Mœnch.	x		
Cornus sanguinea, Linn.	x	...	x
Sambucus nigra, Linn.	...	x	x
Valeriana officinalis, Linn.	...	x	
Eupatorium cannabinum, Linn.	...	...	x
Bidens cernua, Linn.	...	x	
——— *tripartita*, Linn.	x		
Matricaria inodora, Linn.	...	x	
Senecio sylvaticus, Linn.	...	x	
Carduus lanceolatus, Linn.	x	x	
——— near to *palustris*, Hoffm.	...	x	
Lapsana communis, Linn.	...	x	
Leontodon autumnalis, Linn.	...	x	
Taraxacum officinale, Web.	...	x	x
Sonchus arvensis, Linn.	..	x	
Arctostaphylos uva-ursi, Spreng.	...	...	x
Menyanthes trifoliata, Linn.	x	x	x
Myosotis lingulata, Lehm.	x		
Bartsia odontites, Huds.	...	...	x
Pedicularis palustris, Linn.	...	x	
Lycopus europæus, Linn.	x		
Thymus serpyllum, Linn.	...	...	x
Prunella vulgaris, Linn.	...	x	
Stachys palustris, Linn.	x	x	
Galeopsis tetrahit, Linn.	...	x	
Atriplex patula, Linn.	x	x	x
Suæda maritima, Dum.	x		
Polygonum aviculare, Linn.	...	x	
——— *persicaria*, Linn.	...	x	
Rumex maritimus, Linn.	x		
——— *obtusifolius*, Linn.	...	x	
——— *crispus*, Linn.	x	x	x
——— *acetosella*, Linn.	x		
Euphorbia helioscopia, Linn.	...	x	
——— *amygdaloides*, Linn.	x		
Ulmus, sp.	x	...	..
Betula alba, Linn.	x	x	x
——— *nana*, Linn.	...	x	x
Alnus glutinosa, Linn.	x	x	x
Corylus avellana, Linn.	x	x	x
Quercus robur, Linn.	x	x	x
Castanea sativa, Mill.	...	...	?
Fagus sylvatica, Linn.	x		
Salix cinerea, Linn.	x	...	x
——— *repens*, Linn.	...	...	x
——— *herbacea*, Linn	....	x	
——— *polaris*, Wahlb.	...	x	
Empetrum nigrum, Linn.	...	x	
Ceratophyllum demersum, Linn.	x	..	x
Taxus baccata, Linn.	x	..	x
Pinus sylvestris, Linn.	x	x	x
——— *abies*, Linn.	x		

Species.	Pre-glacial.	Inter-glacial.	Post-glacial.
Juncus, sp.	...	x	
Sparganium ramosum, Curtis.	x	x	x
Alisma plantago, Linn.	x	x	
Potamogeton rufescens, Schrad.	...	...	x
——— *heterophyllus*, Schreb.	x	x	
——— *lucens*, Linn.	x		
——— *prælongus*, Wulf.	x		
——— *perfoliatus*, Linn.	...	x	
——— *crispus*, Linn.	x		
——— *pusillus*, Linn.	. .	x	
——— *trichoides*, Cham.	x		
——— *pectinatus*, Linn.	x	x	
Zannichellia palustris, Linn.	x	x	
Eleocharis palustris, R. Br.	...	x	
Scirpus pauciflorus, Lightf.	x	x	
——— *cæspitosus*, Linn.	x		
——— *fluitans*, Linn.	x		
——— *setaceus*, Linn.	...	x	
——— *lacustris*, Linn.	x	x	
——— *maritimus*, Linn.	...	...	x
Eriophorum angustifolium, Roth.	x		
Cladium germanicum, Schrad.	x		
Carex dioica, Linn.	...	x	x
——— *echinata*, Murr.	...	x	
——— *canescens*, Linn.	...	x	
——— *panicea*, Linn.	...	x	
——— *flava*, Linn.	...	x	
——— *paludosa*, Good.	x		
——— *riparia*, ? Curtis	x		
——— *rostrata*, Stokes	...	x	
Anthoxanthum odoratum, Linn.	...	...	x
Agrostis, sp.	...	x	
Holcus lanatus, Linn.	...	x	
Phragmites communis, Linn.	x	...	x
Poa trivialis, Linn.	...	x	x
Osmunda regalis, Linn.	x		
Isoëtes lacustris, Linn.	x	x	x

Nymphæa alba, Linn., from the Cromer Forest-bed *Cratægus oxyacantha*, Linn., Postglacial; *Fraxinus excelsior*, Linn., Postglacial; *Scutellaria galericulata*, Linn., Interglacial; and *Hordeum distichum*, Linn., have been recorded, but Mr. Reid considers the evidence too doubtful to justify their insertion in the above list.

It should be mentioned that the terms Preglacial, Interglacial, and Postglacial are used provisionally, and for the sake of convenience, because at present it is not always possible to separate the Pleistocene from the Recent deposits. H.B.W.

II.—Geological Survey Memoirs.—(1.) The Geology of North Cleveland. By George Barrow, F.G.S. 8vo. pp. 101. Price 1*s.* 6*d.* (London, 1888.)

IN this memoir we have a description of the Yorkshire coast from Whitby to Redcar, and of the northern part of the Cleveland district. Strata from the Red Marls of the Trias to the Kellaways

Rock are described, together with Glacial and Post-glacial deposits; and there are notes on the Cleveland dyke, an augite-andesite, whose intrusion took place probably in Tertiary times.

The Oolitic hills attain an elevation of 1078 feet on Guisborough Moor, while on the coast Boulby or Rockcliff, formed mainly of Lias, is nearly 700 feet high.

The lower beds of the Lias have been proved in borings, but are only exposed at the surface in the "scars" seen at low-tide off Redcar. These beds were, however, described in such detail by Prof. Tate, that our knowledge of the palæontology is very full. The higher beds of the Lower Lias, with *Ammonites Jamesoni*, *A. capricornus*, etc., are briefly described, more detailed descriptions of the strata having been given in the Survey Memoir on the country between Whitby and Scarborough.

From an economic point of view the most important portion of this Memoir is that dealing with the Ironstone Series of the Middle Lias, full details of which are given by Mr. Barrow. In the Upper Lias the Alum industry is now practically extinct, while the introduction of Spanish Jet has almost entirely stopped the local Jet-mining. The *Ammonites* furnish material of much interest. Mr. Barrow observes that a perfect series can be found to show the gradual transition of *Am. communis* to the extreme types of *A. crassus* and *A. Holandrei*: facts which will not be disputed by those familiar with the variable forms obtained in the South of England. The doubtful identification of *A. elegans*, Young and Bird, with *A. concavus*, Sby., is at any rate interesting, while the occurrence of *A. radians* (?), Rein., in the Alum Shale, is also noteworthy.

The variable "Dogger," the base of the Inferior Oolite, occurs on top of the Alum Shale, and is ferruginous and pebbly—the 'pebbles,' it is considered, being waterworn nodules from the Lias. Among other fossils *Rhynchonella cynocephala*, *R. tetrahedra*, and *Terebratula punctata* are recorded from the Dogger in Whitecliff Beck.

The Estuarine Series, grouped with the Inferior Oolite, includes representatives of the Eller Beck Bed and the Grey Limestone Series. The Cornbrash is poorly represented, while the Kellaways Rock is well shown, and yields, among other fossils, *Avicula braamburiensis*, a form characteristic of the marine bands in the Estuarine Series below.

The Drift obliterates all but the most strongly marked geological features of the country. It becomes very thin at heights of 600 feet above sea-level, and disappears altogether above 850 feet. Mr. Barrow concludes, that the ice must have ground over the rocks with no slight force is proved by the fact that at Eston Hill a strip of the Main Seam (Middle Lias Ironstone), some 150 yards long, 50 broad, and 11 feet thick, has been bodily lifted up the face of the hill to a point about 150 feet above its natural outcrop. It is also interesting to learn that the Drift deposits have blocked the old Pre-glacial valleys and forced the streams to form new channels, which they have cut out through deep gorges in the solid rock, in preference to re-excavating their old course through the Boulder-clay.

III.—Geological Survey Memoirs.—(2.) The Geology of the Country around Lincoln. By W. A. E. Ussher, F.G.S., A. J. Jukes-Browne, B.A., F.G.S., and Aubrey Strahan, M.A., F.G.S. (In Part from Notes by W. H Penning, F.G.S., W. H. Dalton, F.G.S., and A. C. G. Cameron.) 8vo. pp. 218. Price 3*s*. (London, 1888.)

A LARGE area is described in this Memoir, including the country around Tuxford, Gainsborough, Lincoln, Market Rasen, Wragby, and Horncastle.

The rocks exposed range from the Bunter pebble-beds to the Chalk, together with Glacial and Post-glacial deposits.

The various divisions are described in detail, and their chief palæontological features are pointed out. The junction of the Lower and Middle Lias, nowhere well marked, is now usually taken by the Survey at the base of the zone of *Ammonites margaritatus*, and above that of *A. capricornus*. It appears, however, that in Lincolnshire and Yorkshire the two species of *Ammonites* occur sometimes together. While the fossils of the Lias are many of them noted with the accounts of the strata, those from the Inferior Oolite (Basement Beds and Lincolnshire Limestone) and the Great Oolite Series are, with few exceptions, enumerated only in the Appendix, so that we have to turn away from the barren account of the rocks to learn, if possible, the prominent fossils which they yield. From the Inferior Oolite two species of *Ammonites* are recorded, *A. Sowerbyi* and *A. læviusculus*. The Cornbrash, Kellaways Rock, and Oxford Clay appear here, as elsewhere, to be intimately connected.

Ammonites Bakeriæ and *A. macrocephalus* are recorded from the Cornbrash. This formation is separated from the Kellaways Rock by a few feet of black shales, grouped with the latter, although regarded as homotaxial with the "Avicula Shales" or Cornbrash Clay of Yorkshire. The following species are recorded from the Upper Oxford Clay near Bardney, forming an interesting assemblage: *Ammonites perarmatus, A. biplex, A. macrocephalus, A. cordatus, A. plicatilis*, etc.

The Lower Cretaceous or Neocomian rocks include the Spilsby Sandstone and the Tealby Beds. The Spilsby Sandstone contains many derived fossils, while among those regarded as indigenous, are *Ammonites Kœnigi, A. mutabilis*, etc. The overlying Tealby Beds are divided as follows:—

Tealby Limestone.
Tealby Clay.
Claxby Ironstone.

These two groups belong to the Speeton Series, and they rest unconformably on the Kimeridge Clay, and are overlain unconformably by the Carstone.

The Carstone is found to be made up very largely of the rolled and washed débris of the Neocomian clays, or where the Carstone is missing, the Red Chalk is found to contain fossiliferous nodules derived from the same source. Evidence is brought forward to

show that the Carstone and Red Chalk indeed pass upwards one into the other.

The various divisions of the Chalk are described, as well as of Glacial and Recent deposits. Numerous records of well-sections and borings, and an account of mineral springs are given in the Appendix.

IV.—I. Etudes sur l'Histoire paléontologique des Ongulés.—II. Le Développement des Equidæ. III. Rhinoceridæ et Tapiridæ. By Marie Pavlow. Bull. Soc. Imp. Nat. Moscou, 1888, pt. 1, pp. 135—180, pls. i. ii.

THE well-known researches of Kovalewsky upon the evolution of the Ungulata are now being continued in Moscow by Madame Marie Pavlow; and the present memoir is the second instalment of results already obtained. The greater portion of the memoir and the plates relate to the development of the Horses; a few pages are devoted to the Rhinoceroses and Tapirs.

Some preliminary remarks upon the earliest Perissodactyles lead to the conclusion that the species already assigned to the so-called *Hyracotherium* are truly referable to three groups:—"1. *Hyracotherium leporinum*, Owen = *Phenacodus leporinus*, characterized by upper molars with six rounded tubercles, and by lower molars with four tubercles connected by feebly marked ribs into two crescents. 2. The other species of *Hyracotherium*, except *H. craspedotum*, Cope, must be placed at the base of the line of Horses. This genus remains characterized by upper molars with six slightly elongated tubercles, of which the contours are less well marked than in the preceding form; lower molars exhibit two distinct crescents, but do not possess the double tubercle (aá, Rütimeyer). Lastly, 3. *Pachynolophus siderolithicum* (= *Hyracoth. siderolithicum*) generically follows the *Hyracotherium* proper, and may be distinguished by the six tubercles of the upper molars being united into two crests, and by the appearance of the double tubercle (aá Rütim.) on the lower molars—a character peculiar to the Equidæ."

A critical review of previous researches upon the evolution of the Horses next follows, and Madame Pavlow concludes that it is most unreasonable to suppose that the Pleistocene Horse of the New World was developed from a line of ancestors independent of that culminating in the modern Horse of the Old World, preferring rather to account for difficulties by a theory of migration. The authoress also adopts the view of Schlosser, that *Palæotherium* cannot be placed in the direct ancestral line of the Horse; and the genus *Anchilophus* is substituted as the most likely immediate predecessor of *Anchitherium*, so far as can be judged from known forms. An interesting discussion of the teeth and limb-bones of *Hipparion* also results in the conclusion that that genus cannot be regarded as a direct ancestor of *Equus*. Madame Pavlow points to the plicated character of the enamel folds and the distinct separation of an antero-internal denticle in the teeth of *Hipparion*, and considers that this genus bears the same relation to the Horse that *Elasmotherium* holds with respect to the Rhinoceros. "The teeth of *Anchitherium*, in

their development, have had no need of passing by the stage of *Hipparion* to arrive at *Equus*; their evolution in this direction has given the form of the teeth of *Merychippus*, *Protohippus* and *Equus*, in the proper sense of the name; and in this chain, it has not been necessary for any of the essential parts of the molars to disappear in order to re-appear later, or to develop parts completely new and different." *Hipparion*, indeed, is to be looked upon as "a form which became separated from the direct Equine series before the evolution of the *Equus*-type was complete, and perhaps even before *Anchitherium aurelianense*."

A study of the milk-teeth of the successive genera supposed to be ancestral to the Horse seems to lead to at least three conclusions, as follow: —"1. The milk-molars are not a repetition of the premolars of the preceding form, but, on the contrary, foreshadow the premolars of a new form which is to follow; 2. The difference between the milk-teeth and the premolars of one and the same form is greater in proportion to its antiquity; 3. The resemblance between the milk-teeth and the premolars in two successive forms is closer in proportion to their antiquity."

A table showing the known geographical and geological distribution, with the supposed relationships, of the several Equine genera is appended; and Madame Pavlow promises to supplement the work shortly by a memoir upon the Pleistocene horses of Russia.

The section (III.) upon the Rhinocer[ot]idæ and Tapiridæ is mainly a synopsis of the literature of the subject; and this appears to show that *Systemodon*, of the North American Eocene, is an immediate predecessor of the families under discussion, while *Hyrachyus* also is a missing link. A. S. W.

CORRESPONDENCE.

A PLEA FOR A UNIFORM SYSTEM OF ABBREVIATION WHEN QUOTING SCIENTIFIC PERIODICALS.

SIR,—It would be not only a great convenience to scientific students in general, but a much more satisfactory proof of the acquaintance of an author with the book he refers to, if some uniform system of abbreviation were adopted when quoting scientific literature. It is exceedingly perplexing to find variants in the abbreviation of a book-title, and has often caused considerable trouble and annoyance to those coming across them for the first time. A few years ago writers had some excuse for these and similar carelessnesses, inasmuch as no list of abbreviations had then been published, but when in 1874 W. Whitaker and W. H. Dalton issued the first volume of the Geological Record, they gave an excellent list of abbreviated titles, supplying the want of a book of reference, and leaving no excuse for "sloppy" quotation. This list has been further enlarged and improved in the volume for 1880–84, just issued, and may be taken, with very few exceptions,[1] as an absolutely safe set of abbreviations, each being distinct and

[1] It is always advisable to quote the *place* of publication in full in a scientific title.

definite. In the November Number of the GEOLOGICAL MAGAZINE one cannot help being struck by the slip-shod system of reference used by two of the writers; *e.g.* "Tsch. Min. Mitt." is absolutely meaningless except to those who know the book; "Bull. Imp. Mosc." may refer to any Moscow society as no definite one is quoted.

Another source of inconvenience is seen in the reference to authors:—Prof. Judd, Prof. Bonney, Mr. Teall, etc., for example, how much more definite would it be to refer to these and any writer by initials as J. W. Judd, T. G. Bonney, J. J. H. Teall? We find much fault with our French and German colleagues for the vexatious system of printing surnames only, thus causing endless misquotation and confusion in library cataloguing, and yet ourselves permit it in our own scientific publications. The perfection of quotation, on the other hand, is seen on pp. 496–501 of the same number of the GEOLOGICAL MAGAZINE, and proves unmistakeably that the writer is familiar with the books he refers to. C. DAVIES SHERBORN.

CONE-IN-CONE STRUCTURE IN A COAL-SEAM.

SIR,—What is commonly known as "cone-in-cone coal" or "crystallized coal" has, I presume, nothing to do with true cone-in-cone structure here referred to. Through a friend of the writer's, a small concretionary mass of iron pyrites taken from the "Roaster" coal-seam near Ashby-de-la-Zouch, Leicestershire, has come into his hands for examination. Externally the specimen has very much the aspect of a roughly rounded pebble, and is nearly black in colour, measuring $1\frac{1}{2}$ inch in diameter, and about $\frac{3}{4}$ inch thick vertically. Having had the stone cut horizontally through the middle, cone-in-cone structure showed itself in places around the outside; in fact, the specimen appears to be nearly wholly made up of the same structure, though only at all well developed near the surface.

Whether the theory put forward by Mr. John Young, F.G.S., of Glasgow, and published in this MAGAZINE, can or cannot account for the cone structure here seen, I leave others to judge; merely remarking that in my opinion some other explanation of the phenomenon must be found.[1] W. S. GRESLEY, F.G.S.

OBITUARY

PROFESSOR THEODOR KJERULF.

BORN MARCH 30TH, 1825; DIED OCTOBER 25TH, 1888.

WE regret to record the death, in Christiania, his native city, of Prof. Theodor Kjerulf, after a lingering illness. He was brought up and educated in Christiania, and after the completion of his University studies, spent some time in Iceland; he then went to Germany, where he studied in the laboratory of Bunsen, and at the same time pursued some geological investigations in the Harz and Tyrol. Returning to his native city, he commenced the study of the

[1] See W. S. Gresley, Note on "Cone-in-Cone" Structure, GEOL. MAG. 1887, p. 17. John Young on "Cone-in-Cone" Structure, GEOL. MAG. 1885, p. 283. Prof. J. S. Newberry on "Cone-in-Cone" Structure, GEOL. MAG. 1885, p. 559. John Young's reply to Prof. Newberry, GEOL. MAG. 1886, p. 139.

marvellous geological structure of the Christiania basin, of which the results appeared in the work entitled, "Das Christiania-Silurbecken, chemisch-geognostisch Untersucht" (1855). In 1858, Kjerulf became Professor of Geology in the University of Christiania, and shortly afterwards he initiated and organized the Geological Survey of Norway, to which he was appointed Director, and he continued to hold this post as well as the University Professorship till his death.

Dr. Kjerulf's most important work in connection with the Geological Survey, entitled "Udsigt over det sydlige Norges Geologi," appeared in 1879. In this the results of 20 years' observations of the Survey in the Southern part of Norway were summarized. The work was accompanied by an atlas of 39 plates and a geological map, and it is a mine of facts relating to the rock-formations of this country—from the Archæan gneiss to the Post-Glacial clays—their history, the fossils contained in them, the age and character of the eruptive rocks, etc. Dr. Kjerulf was also the author of numerous other important papers, mainly on the geology of Norway, which appeared at intervals between 1855-1885. Amongst these may be mentioned, "Ueber die Geologie des Südlichen Norwegens, mit Beiträgen von Tellef Dahll, 1857;" "Veiviser ved geologiske excursioner i Christiania omegn, 1865;" and "Ueber die Terrassen in Norwegen und deren Bedeutung für eine Zeitberechnung bis zur Eiszeit zurück," of which an English translation was made by Marshall Hall (Geol. Mag. 1871, pp. 74–76). Dr. Kjerulf, in his "Meraker profilet," and in several other Memoirs, has fully described the very interesting series of older Palæozoic and Archæan rocks in the district around Trondhjem, Roraas, etc. He was deeply interested in the glacial phenomena, so strikingly shown in Southern Norway, and in addition to several papers of his own on this subject, was associated with Dr. M. Sars in writing the "Iagttagelser over den Postpliocene eller Glaciale formation i en del af de sydlige Norge, 1860."

Dr. Kjerulf's services to Geological Science were known and appreciated far beyond his native land. He was chosen a Foreign Correspondent of the Geological Society of London in 1864, and Foreign Member in 1875.

THE LATE W. H. BAILY, F.L.S., F.G.S.

Sir,—In the Obituary of Mr. Baily, which appeared in the Geological Magazine for September last, p. 431, the List of his Works was omitted. I now send it for favour of insertion.—H.B.W.

1855.—1. Description of some Cretaceous Fossils from South Africa, collected by Captain Garden, Quart. Journ. Geol. Soc. vol. xi. pp. 454-465.
2. Description of Fossil Invertebrata from the Crimea, *op. cit.* vol. xiv. pp. 133-163.
3. On a Crustacean from the Coal-measures, with some remarks on the genus *Limulus*, Journ. Dublin Geol. Soc. vol. viii. pp. 89-91; Nat. Hist. Rev. vol. v. pp. 168-171.
4. Notice of Upper Silurian Fossils from Ballycar South, county of Clare, Journ. Dublin Geol. Soc. vol. viii. pp. 109, 110; Nat. Hist. Rev. vol. vi. pp. 72, 73.
5. On Carboniferous Limestone Fossils from county Limerick, Rep. Brit. Assoc. for 1857, Sections, pp. 62, 63.
6. On Fossil Localities near Drogheda, Journ. Dublin Geol. Soc. vol. viii. pp. 120-125.

1859.—7. On the occurrence of detached plates of the shell of a new species of *Chiton* in the Carboniferous Limestone at Lisbane, county of Limerick, Journ. Dublin Geol. Soc. vol. viii. pp. 167-171; Nat. Hist. Rev. vol. vi. pp. 330-334.

8. On the Fructification of *Cyclopteris Hibernica*, Forbes, from the Upper Devonian or Lower Carboniferous strata at Kiltorkan Hill, county Kilkenny, Rep. Brit. Assoc. for 1858, Sections, pp. 75, 76.

1860—9. On a new species of Pentacrinite from the Oxford Clay, Weymouth, Dorsetshire, Dublin Zool. Bot. Assoc. Proc. vol. ii. pp. 19-23.

10. On fossil *Chitonidæ* and their distribution in geological time, Dublin Zool. Bot. Assoc. Proc. vol. ii. pp. 40-47.

11. On a new species of *Solarium* from the Upper Greensand near Dorchester, Dublin Zool. Bot. Assoc. Proc. vol. ii. pp. 66, 67.

12. On *Corynepteris*, a new generic form of Fossil Fern; with observations on the associated plants from the Coal-measures of Glin, county of Limerick, Journ. Dublin Geol. Soc. vol. viii. pp. 237-241.

13. On *Sphenopteris Hookeri*, a new Fossil Fern from the Upper Old Red Sandstone formation at Kiltorkan Hill, in the county of Kilkenny; with some observations upon the Fish-remains and other associated fossils from the same locality, Rep. Brit. Assoc. for 1859, Sections, pp. 98, 99.

1862.—14. On the occurrence of some characteristic Graptolites and other fossils, indicating certain divisions of the Lower Silurian rocks in the counties of Meath, Tipperary, and Clare, Journ. Dublin Geol. Soc. vol. ix. pp. 300-306.

1863.—15. Baily, W. H. and A. Carte, Description of a new species of *Plesiosaurus*, from the Lias, near Whitby, Yorkshire, Journ. Dublin Geol. Soc. vol. iv. pp. 161-169.

16. On two new species of Crustacea (*Bellinurus*, Koenig), from the Coal-measures in Queen's County, Ireland; and some remarks on forms allied to them, Ann. and Mag. Nat. Hist. vol. xi. pp. 107-114.

17. Notes on the fossils collected by Mr. Wynne in the counties of Sligo and Leitrim, Journ. Dublin Geol. Soc. vol. x. pp. 40, 41.

1864.—18. On the occurrence of Fish-remains in the Old Red Sandstone at Portishead, near Bristol, GEOL. MAG. Vol. I. p. 293; Rep. Brit. Assoc. for 1864, Sections, pp. 49, 50.

1865.—19. On some new points in the structure of *Palæchinus*, GEOL. MAG. Vol. II. pp. 44, 45.

20. The Cambrian rocks of the British Islands, with especial reference to the occurrence of this formation and its fossils in Ireland, GEOL. MAG. Vol. II. pp. 385-400.

1866.—21. The recent discovery of fossil reptiles in the Coal of the south of Ireland, GEOL. MAG. Vol. III. pp. 84-86.

22. On Salter's Appendix to vol. iii. of the Memoirs of the Geological Survey of Great Britain, *ibid.* pp. 477, 478.

1867-1875.—23. Figures of Characteristic British Fossils: with Descriptive Remarks, vol. i, Palæozoic, with 42 plates and 18 woodcuts. 8vo. London (Van Voorst).

1869.—24. Notice of Plant-remains from beds interstratified with the Basalt in the county of Antrim, Quart. Journ. Geol. Soc. vol. xxv. pp. 162.

25. Notes on Graptolites and allied Fossils occurring in Ireland, Quart. Journ. Geol. Soc. vol. xxv. pp. 158-162.

1871.—26. On the Fossils of the Ballycastle Coal-field, co. Antrim, Journ. Geol. Soc. Ireland, vol. ii. pp. 270-275.

1873.—27. Remarks on the Genus *Pleurorhynchus*, with a description of a new species (*P. Koninckii*), Journ. Geol. Soc. Ireland, vol. iii. pp. 24, 25.

28. Additional Notes on the Fossil Flora of Ireland. On *Filicites plumiformis*, n.s., from the Carboniferous Limestone near Wexford, Journ. Geol. Soc. Ireland, vol. iii. pp. 48-51.

1874.—29. Sketch of the Geology of Belfast and the Neighbourhood, Science Gossip, No. 116, pp. 169, 170.

30. Palæozoic Echinida: *Palæchinus* and *Archæocidaris*, Journ. Roy. Geol. Soc. Ireland, ser. 2, vol. iv. pp. 40-43. (2 plates.)

1875.—31. On Fossils from the Upper Old Red Sandstone of Kiltorkan Hill, in the county of Kilkenny, Proc. Roy. Irish Acad. ser. 2, vol. ii. pp. 45-48.

1876.—32. Description of a new species of Labyrinthodont Amphibian from the Coal at Jarrow Colliery, near Castlecomer, Kilkenny, Rep. Brit. Assoc. for 1875, Sections, p. 62.

1878.—33. Lists of Fossils in "Manual of the Geology of Ireland," by G. H. Kinahan, M.R.I.A., etc.

34. Sketch of the Geology of Dublin and Wicklow, Sci. Gossip, No. 164, pp. 179-183.

35. On the Palæontology of County Dublin, Journ. Roy. Geol. Soc. Ireland, vol. xv. pp. 78-98.

1879 & 1883.—36. Notice of some additional Labyrinthodont Amphibians and Fish from the Coal of Jarrow Colliery, near Castlecomer, county of Kilkenny, Ireland, Rep. Brit. Assoc. for 1878, Sections, p. 530, *op. cit.* 1883.

1880.—37. Report of the Committee appointed for the purpose of Collecting and Reporting on the Tertiary (Miocene) Flora, etc., of the Basalt of the North of Ireland, Rep. Brit. Assoc. for 1879, pp. 162-165.

1881.—38. Second Report, *ibid. op. cit.* 1880, pp. 107-109.

1883.—39. Third Report, *ibid. op. cit.* 1881, pp. 152-154.

40. Report on the Rocks of the Fintona and Curlew Mountain Districts (jointly with G. H. Kinahan, M.R.I.A.), Proc. Roy. Irish Acad. ser. 2, vol. iii. (Science).

1885.—41. On Trilobites and other fossils from Lower and Cambro-Silurian strata, in the county of Clare, Scientific Proc. Royal Dublin Soc. new ser. vol. iv. p. 373.

42. On a new species of *Orophocrinus* (*Pentremites*), in Carboniferous Limestone, county Dublin; also remarks upon *Codaster trilobatus* (M'Coy) from Carboniferous Limestone, county Kilkenny, Scientific Proc. Royal Dublin Soc.

1886.—43. Rambles on the Irish Coast, especially relating to the Geology, Natural History, and Antiquities in the neighbourhood of Dublin (map and ten woodcuts).

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